SHIP PRODUCTION COMMITTEE
FACILITIES AND ENVIRONMENTAL EFFECTS
SURFACE PREPARATION AND COATINGS
DESIGN/PRODUCTION INTEGRATION
HUMAN RESOURCE INNOVATION
MARINE INDUSTRY STANDARDS
WELDING
INDUSTRIAL ENGINEERING
EDUCATION AND TRAINING

June 1978
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THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

REAPS 5th Annual Technical Symposium Proceedings

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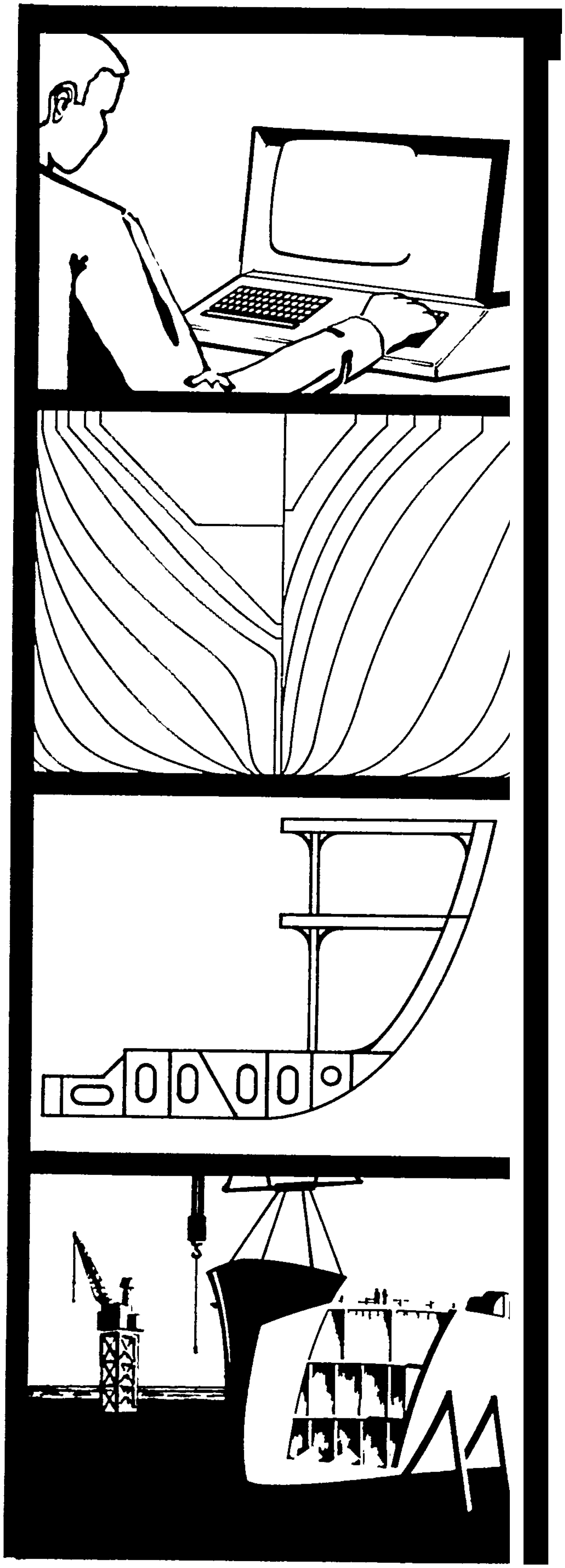

RESEARCH
AND
ENGINEERING
FOR
AUTOMATION
AND
PRODUCTIVITY
IN
SHIPBUILDING

Proceedings of the REAPS Technical Symposium

June 27-28,1978

St. Louis, Missouri

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Research and
Engineering for
Automation and
Productivity in
Shipbuilding

IIT RESEARCH INSTITUTE
10 WEST 35 STREET
CHICAGO, ILLINOIS 60616

Thee Sixth Annual REAPS Technical Symposium will be held in San Diego, California in August 1979.

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PREFACE

The REAPS Program is a U.S. shipbuilding industry/Maritime Administration cooperative effort whose goal is the improvement of shipbuilding productivity through the application of computer aids and production technology.

The Fifth Annual REAPS Technical Symposium, held June 27 and 28, 1978 in St. Louis, Missouri, represents one element of the Program which is designed to provide industry with the opportunity to review new developments in shipyard technology. The Symposium was attended by representatives of some 63 shipyards and supporting organizations.

We are indebted to the many people at St. Louis Shipbuilding and at McDonnell Douglas who were involved in the plant tours offered to symposium registrants. Their efforts, and those of their respective managements in authorizing the tours, are sincerely appreciated.

The <u>1978 REAPS Technical Symposium Proceedings</u> contain most of the papers presented at the meeting. The agenda in Appendix A indicates topics and speakers; Appendix B is a list of symposium attendees.

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WELCOME

Marvin Pitkin
Maritime Administration
Washington, D.C.

Mr. Pitkin is the assistant administrator for commercial development at MarAd. He is responsible for four research and development offices, the Office of Ports and Intermodal Development, and the Office of Market Development. He has a degree in mechanical engineering from New York University.

Mr. Pitkin has received the Navy's second highest award for "Meritorious Civilian Service" and the Department of Commerce's highest award, the. DOC Gold Medal Award.

M. PITKIN
ASSISTANT ADMINISTRATOR FOR COMMERCIAL DEVELOPMENT
MARITIME ADMINISTRATION

Welcome to the fifth Annual REAPS Symposium On the application of computer and automation technology. to shipbuilding.

Many of the people here today can remember when the first REAPS Symposium was held in Baltimore, Maryland back in 1973. The use of computer and automation technology to improve productivity in United States yards, at that time, was in its infancy. Now, barely 5 years later, all of the major United States yards--and many of the smaller yards as well--are on line using these technologies to reduce cost and increase productivity. Five years ago we were all somewhat nervous; uncertain of the benefits, uncertain of our ability to absorb this sophisticated technology. This nervousness is now behind us. Even a casual glance at the technical program for these next 2 days shows the marked tendency to explore and develop new ways to exploit this technology beyond lofting and numerical-controlled burning machines.

I like to think that REAPS, and particularly these annual symposiums, are responsible for our new-found confidence to employ--at a profit--the most advanced technologies in the world for building ships. These are meetings of your peers; and, if nothing else happens, we go back to our jobs with the conviction that, if the other guy can do it, I can do it better.

In 1973, when the Maritime Administration asked United States shipyards to participate as a body in REAPS., it was a recognition that the mere handful of individuals within our industry who were knowledgeable in these technologies could not carry off the necessary transition alone. We felt that it would be necessary for the

industry to combine these scarce resources on an industrywide scale to raise tlhe level of knowledge within the industry. All one has to do is look about this room so as to see the growth of this handful of people into the hundreds who now use and manage computer technology routinely in shipbuilding today. But the Maritime Administration has an additional goal. Our job within the Federal Government is to assist United States shipbuilders to reduce cost and improve productivity. To do our job right, industry in turn must have the mechanisms to form a consensus of their need to accomplish our joint purpose. The self-adaptive frame bender and semiautornated pipe shop are examples of projects which were identified within the REAPS group and brought to their present stage with the assistance of the Maritime Administration.

What can we expect in the future from REAPS? For one thing, we expect they will continue the good work they have started. With the current depressed state of shipbuilding, many of you may ask what is the point. To be sure we are still in the throes of a world-shipping recession which has plagued the industry since 1974. However, there are signs that should not be overlooked. Shipbuilding activity on the Great Lakes is booming--10 large ore carriers and two Ro/Ro's on order or under construction. Add conversions and repairs and the backlogs stretch through the mid-80’s for some yards. Elsewhere Bath and Todd share an order for 28 navy frigates and they could get 26 more. From June 1976 through September 1977 subsidized orders were placed for a total of 13 new ships. We expect 13 more from the 1978 and 1979 programs. Our backlog is still decreasing but new orders are beginning to pick up. We have lots of problems, but we are also one tough industry.

This may be the time and opportunity for the industry--with the help of the Maritime Administration to break the age-old syndrome that has plagued shipyards for generations; that is, when business is good, no one has time to make changes, and when business is bad, no one has the resources or incentive necessary to bring them about.

For the past 5 years the touchstone for the REAPS group has been technology development. Now we look further upward. Today there is a growing. awareness that ,productivity improvement contains elements in addition to advanced technology; for examPle, we know that the attitudes and motivation of the work force must be addressed. Another example,; we know the ability to raise the capital necessary to implement advanced technology will be a continuing problem and one which we must solve (this was a problem even when business was good, but it is especially critical when it is uncertain in the yard as to where the next ship order is coming from). We in the Government must-work together with management (particularly the management of production operations) to take full advantage of advances once achieved. I am confident that in the years to come the REAPS group, along with the Government organizations interested in improving United States shipbuilding; will" begin addressing these subjects. REAPS has made a very successful start, let us keep the movement going. I certify to you that both industry and Government are impressed by the initiatives you have taken and the positive sense of cooperation you have fostered. Within industry you have established their credentials. Keep that flag flying, fellers--

Thank you.

A PROGRESS REPORT ON THE REAPS PROGRAM

Doug Martin
IIT Research Institute
Chicago, Illinois

Doug Martin is the manager of Shipbuilding Technology at IIT Research Institute.

He has his degree in Naval Architecture from the University of Michigan.

Currently he is responsible for the management of the REAPS program as well as other projects in computer aids to shipbuilding, computer aided design and shipyard manufacturing technology.

His previous experience includes the development of computer graphics systems for ship design and lofting applications, software for marine transport system economic analysis and a software system for real time model test data acquisition and analysis.

Doug will update us on the REAPS Program.

PRESENTATION OUTLINE

1. Showing of film describing REAPS Program

2. 1978 REAPS Program Participants: see Figure 1

3. REAPS Research and Development Projects Status

   3.1 Active projects during past year [see Figure 2)
   3.2 The first four projects listed to be described in detail in other Symposium presentations
   3.3 Damaged Stability Program

   - Completed during the year
   - Features:

     Variety of damaged stability analyses can be performed
     Allows complex compartment geometry definition
     Operational on UNIVAC 1108, IBM 370, Honeywell 6000

   3.4 Cold Twist Forming of Shapes

   - Completed during year
   - One-fifth scale dies developed for use in hydraulic press to demonstrate feasibility of cold twisting process (see Figures 3 and 4)
   - Feasibility was proven - Newport News now building full-scale dies

   3.5 Graphics and Communications Terminal

   - Simultaneously processes remote job entry (RJE) jobs and N/C verification graphics
   - Software developed by REAPS staff
   - Installed on minicomputer system purchased by Bethlehem Steel (see Figures 5 and 6)
   - Delivery August 1978

   3.6 Plate Marking Device

   - Device to retrofit on N/C flame cutters to automatically apply a permanent piece identification to N/C cut parts
   - Prototype design developed
   - N/C flame cutter manufacturers being solicited to build the device

BATH IRON WORKS

BETHLEHEM STEEL CORP.

GENERAL DYNAMICS CORP.

McDERMOTT SHIPYARD

NATIONAL STEEL AND SHIPBUILDING CO.

NEWPORT NEWS SHIPBUILDING AND DRY DOCK CO.

PETERSON BUILDERS, INC.

SUN SHIPBUILDING AND DRY DOCK CO.

FIGURE 1: 1978 REAPS PARTICIPANTS

COMPUTER AIDED COST ESTIMATING (NASSCO)

"RAPID" PIPE DETAILING SYSTEM (NNS&DD)

HULL DEFINITION FAIRING PROGRAM (NNS&DD)

PARTS DEFINITION SYSTEM (NNS&DD)

DAMAGED STABILITY PROGRAM (BETHLEHEM)

TWIST FORMING OF SHAPES (IITRI)

GRAPHICS AND COMMUNICATIONS TERMINAL (IITRI)

PLATE MARKING (IITRI)

FIGURE 2: REAPS R&D PROJECTS

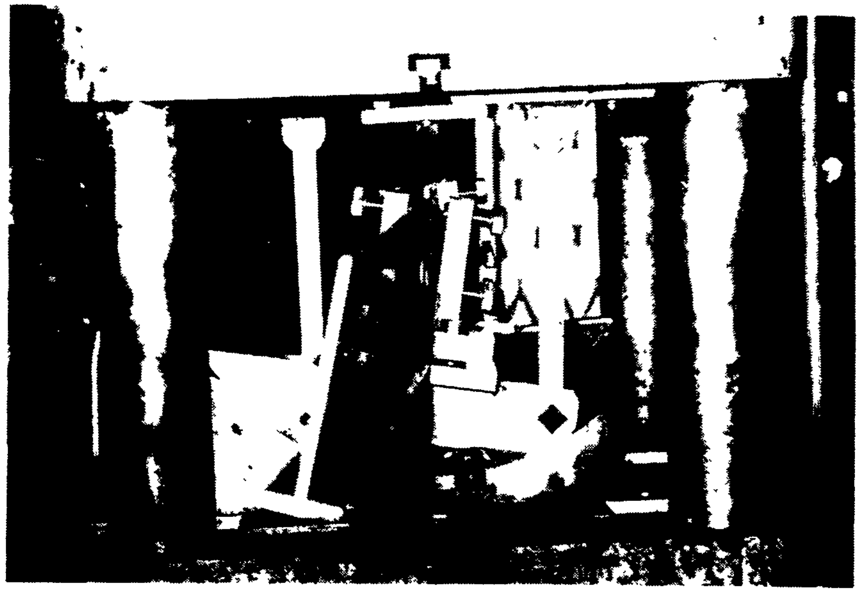

FIGURE 3: PROTOTYPE TWIST DIE ARRANGEMENT

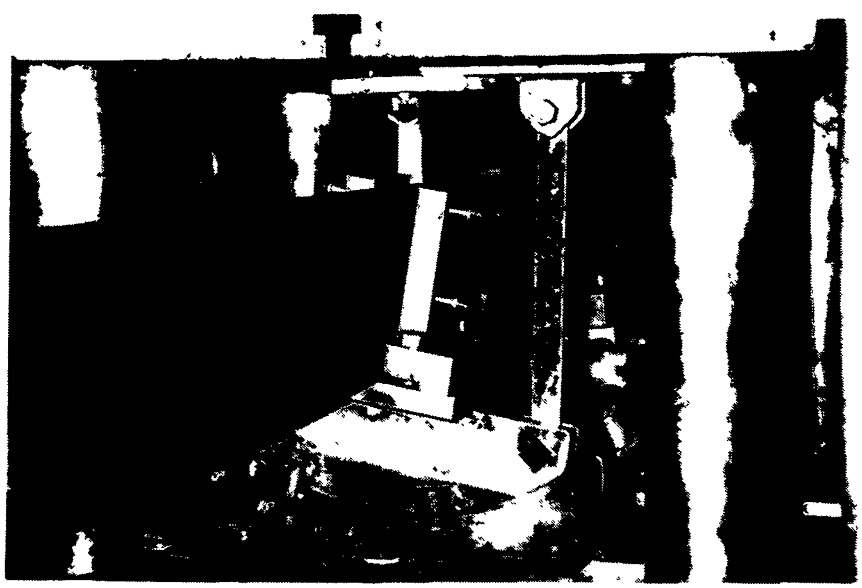

FIGURE 4: TEST PIECE IN DIES SHOWING WORK SEGMENTS

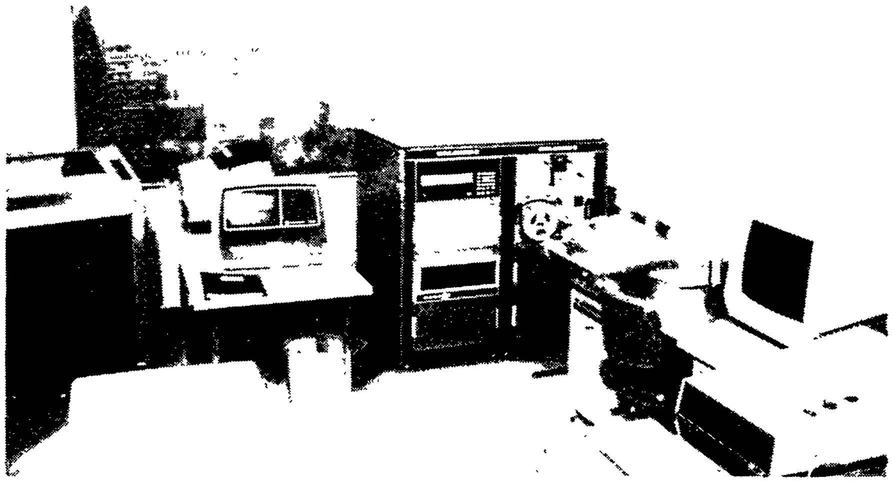

FIGURE 5: TERMINAL MINICOMPUTER SYSTEM

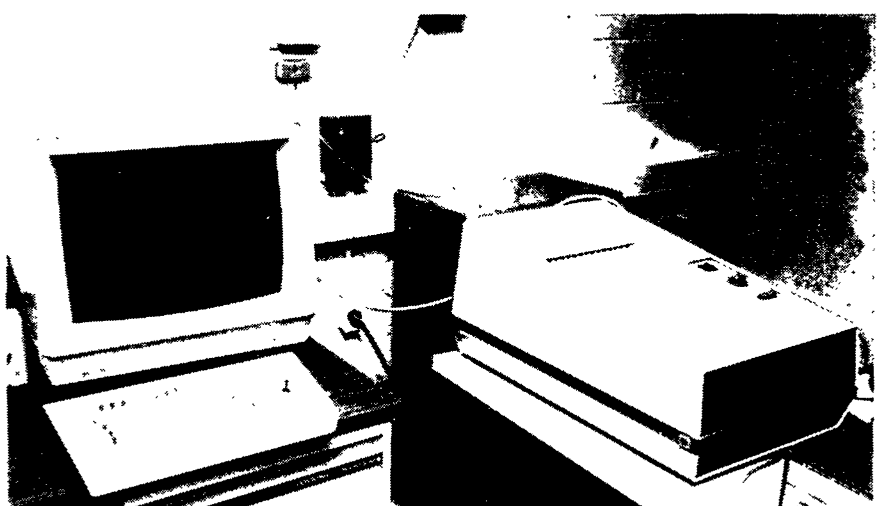

FIGURE 6: TERMINAL CRT AND HARDCOPY UNIT

REDUCING PRODUCTION MAN-HOURS
THROUGH DESIGN OFFICE PROCEDURES
STRUCTURAL DESIGNER-FABRICATOR RELATIONSHIP

Thomas P. Gallagher
Naval Ship Engineerinng Center
Washington, D.C.

Mr. Gallagher is NAVSEC HullStructure$ Head of Research Dynamics for High Performance Craft. He is responsible for the structural design of PHM hydrofoil, SES surface effect ship, LCAC air cushion landing craft, SWATH planning landing craft and standard landing craft.

His previous experience with NAVSEC includes the hull structural design of various combat and auxiliary ships, managing the development of CASDOS, and submarine design.

REDUCING PRODUCTION MANHOURS THROUGH DESIGN OFFICE PROCEDURES STRUCTURAL DESIGNER FABRICATOR RELATIONSHIP

Abstract: The shipyards in this country have spent a sizable amount of money to modernize their methods of fabrication to increase construction. The shipbuilding industry is a labor hitensive business based on small orders of ships that does not allow for total automation in the near term, if ever. One area of a shipyard that has minor or limited changes is the structural design office. The manual drafting of working drawings is basically the same as the methods used in the 1950's. A number of yards have restructured the working drawing to assembly type drawings. This is a major change assisting in the construction of the ship, but is still limited in scope. The present method does not allow for an orderly progression into the application of computers. The development of working drawings to assist construction is-poor and this stagnation has restricted the design. office from converting drawings to computers.

The problem stems from false economy values. The idea that a limited budget for the development of working drawings will increase the yard's profit margin is a false one. Every effort, or person hour, used in design should have a direct savings in production manhours. The goal of the designer's output should be a necessary and direct part of the construction program. Many design offices may not even realize that they are not truly reducing costs, but are driving them up due to poor dettailing. (A complete study of the working drawing process should be made objectively by design, production and planning people). This paper may give the basic outlines for consideration. Thomas P. Gallagher, Surface Ship Structures, Head, Research, Dynamic/Highedr Performance Craft Section, Phone 202-692-9107, Naval Ship Engineering Center.

DESIGNER – FABRICATOR RELATIONSHIP

Introduction - Over the past five years, the author has had the opportunity to participate in the development and implementation of a special computer system. It had, as its goal, the reduction of shipbuilding costs through automation of the design, detailing and fabrication process. During this time some observations and conclusions have been developed concerning the interrelationship of the design offices and the building yard and how the present process and attitudes must be changed if we are to realize the full potential of modern technology available through the computer and numerically controlled equipment. It is hoped that the thoughts expressed in this paper will be perceived as an overview of one who can understand the reluctance of men to change, despite the necessity to do so, and not as a criticism of an industry that has performed so well over the years.

Where to begin - The traditional design process requires that upon completion of a design, competitive bids are received and a contract let to build the ship. The yard winning the competition will require an in-house engineering staff, a design agent, or both, to develop the working drawings. He will require a production department to plan construction and shops to do the myriad of jobs required to finally develop a constmcted ship. To be most effective the working drawings should be developed with production in mind.

To be most effective, production should be kept in mind when the working drawings are being developed.

Shipbuilding today is still a construction rather than a production industry. This equates to the difference between house construction as to automobile production. If automobiles were constructed, instead of produced, we would pay a minimum of 3 to 5 times the cost with more problems than we have today. Shipbuilding is a labor intensive industry which has a high cash flow that should require a positive change to production instead of the stick by stick construction so familiar today.

Shipyards have made many changes in their method of construction, but, in most cases, have not carried the changes back up stream to include the engineering or design process. The need to convert more shipbuilding to production, rather than construction, is a major way of reducing costs. The advancement of ship construction methods must be reflected back into the working drawing and contact design process. The time and money this could save, even with manual drafting methods, when properly managed, would be of a major magnitude. A design agent may find this more difficult than a yard with inhouse design services, but the difficulties could be minimized with a proper interface. The design agent may require ,different drawings for different yards building the same ships to suit their special practice. Under a manual method most detailed information could be copied or traced, while with a computer database, a modification to general assembly instructions would be required.

Today, some yards have assembly type drawings while others have stayed with their conventional systems. The conventional method of working drawing development is basically for the ease of the designer and not the need of the shipbuilder. This may take time to realize but let us consider the problem using conventional methods: how rnany drawings is a deck made up of and why. Generally, it is based on the length of ship and the scale of the drawing. Design offices have been known to use drawings 12 feet or less because of the Iengh of drawing boards, or because of the reproduction process. In some yards the answer may be that we have held to this size since the war. One reason for lack of progress in the design area, is the shipyards allow the design office to develop the drawings to suit themselves. Most shipyards realize this. They have systems to compensate for the situation, such as the use of revision or modification notices, and shop sketches to update and breakdown the working drawings. In reality it is to work around the poor practice in a design office. Part of the problem is design and production are under different heads. They may have equal status in the organization but this does not allow the production head to require a change in design process to suit inhouse production. On designs with a design agent the problem is money, based on the least cost of detail drawings.

Restructure of a shipyards design and construction methods could be accomplished by establishing new ground rules. When a new ship contract is awarded for a certain class of ship, the design office must prepare a schedule of working drawings. Under Navy specifications this list is required 120 days from award. Prior to award, shipyards do not review the contract package in detail to finalize a construction schedule, or more important, the method of construction. This is the first problem that starts the wheels of progress turning in different directions. The shipyard planning office is dividing the ship up for a possible construction schedule required 150 days from award while the design office is dividing the hull to suit a design schedule, Without proper interface, no change in the working drawing process will be made. One solution to this problem would be a change in the Navy requirements. This change would allow for the drawing schedule to slip from 30 to 60 days after the fabrication and erection schedule, and early drawing schedules would establish guidelines not firm milestones.

This would open up a new avenue that would enhance the overall construction process. The drawings would truly reflect the method of construction. A step further would be to. divide the ship in the area of transverse bulkheads. The various compartments would become assemblies, and from then on the ship would always be treated as an assembly. The first or second transverse bulkheads forward would be Assembly #1, the next one, or two, transverse bulkheads would make up Assembly.#2, and the machinery spaces would be a complete assembly. The superstructure could be one (1) or two (2) assemblies, based on complexity, Some shipyards build the superstructure early, as it is quick to erect. This gives them added storage area during construction when storage, not land, is a problem.

A simple layout of the shell and decks would be required to run the longitudinal members and plate seams. The contract drawing or modification of them could be used for this purpose. This could then be subdivided in accordance with the assembly approach.

A small profile drawing with as assembly areas noted and approximate frames are given to insure everyone works and understands that assembly. This is not a new idea as it was used on Victory ships to help new People to become familiar with the output of the ship. This is a simple tool that is a great help. See Figure 1.

This method of drawing development has done many things. First, with limited manpower two (2) or three (3) designers can develop an assembly. When an area of the ship is complex, structurally, the assembly should be a smaller area. Where an assembly is generally habitability, machinery, electronics, or missile spaces, the only structural drawing required would be available as a package. See Figure 2. The different surfaces would be the main and 2nd deck Assembly #2; port shell Assembly #2, starboard shell Assembly #2; and transverse bulkheads Assembly #2. This now allows changing piece marking method to comply with the new assembly approach. All of **Assembly #I** would have 1,000 numbers, Aisembly #2 would have 2,000 numbers. In most hulls this would be a viable system and would help control the job by using lots in the fabrication shops. The next breakdown would be by surface, such as deck shell, web frames and miscellaneous structures with the second number indicating this level. All the pieces on the deck could be 1100 to 1299, and 1300 to 1399 for the stiffeners on the starboard shell, with the next hundred piece numbers being the port shell. Another positive feature is the resulting standardization of the piece numbers from assembly to assembly. Care should be taken when assigning piece numbers, as each insignificant piece number would add costs to an assembly. The piece numbers should be based on a family of parts not a separate identification.

A number of advantages have been gained, as follows:

1. We have utilized the hull in the same manner as the ship is laid out and constructed. Associated systems have complete packages to run their services. The drawings reflect the erection schedule and will allow for an earlier start up.

2. We have restricted, or limited, the concern for the designers. This alone is of utmost importance because an assembly leader, or senior designer, could be assigned the responsibility of one or more assemblies, assisted by junior men in the actual development.

Revisions on structural drawings are usually done because of associated drawings. Having invoked the assembly method, all associated structured drawings are in the same assembly package. One revision covers the deck, shell, bulkheads, web frame and miscellaneous bulkheads. In an extreme case let us assume a change affected all of these surfaces. The conventional approach would require design groups, and production people, to wait for five dfiferent drawing revisions to complete a cycle. In some yards, the deck drawings are only issued a limited number of times because of the cost of reproduction. With the assembly method, all groups would have a single point of contact to check with the senior designer, that is their assembly leader. In expanding shipyards, this information could be posted, thereby directing employees to the right source.

From the management end, the assembly method would allow a greater control of manpower. Many of the assemblies would be of a similar size and complexity :therefore, measurement of the man could be made based on performance. The possibility of compatibility would markedly increase because all associated plated surfaces would be developed together. Proper development of the bulkheads and platforms would be simplified because the deck and shell associates are within reach all the time. The entire yard will talk in terms of assemblies, not parts. This would reduce the mess that results from hundreds of drawings.

With the suggested change in the design office, the people involved should find they like the small drawing packages. This will allow a great control of associated systems as the structural drawing would indicate major and minor holes in the shell, deck, and bulkhead. It is said that the first step is the hardest. Now that we are on our way, let us consider the reason for development of the drawings, and have the requirements changed.

Looking back over the previous method of assemblies, there was no mention of details. This is very important to insure standardization. The design of details must be controlled, a special detailed drawing developed, and all reference to details will be made on on the assembly drawing, but the detail will only appear in the standard detail book. This should also include the welding requirements for most fillet welds. A great deal of time and money is spent on the repetition of details in a design. Look at all the bulkhead drawings for any ship. The number of repeat details make summer television look good: By using this, we are eliminating personal preference, as the designers were generally trained at different shipyards, and this is a reason for the detailing difference. A supervisor has only to check the detailing booklet and he will know if all assemblies are being detailed in the same manner. This may take a little pride of authorship away, but the competition of the assembly approach should offset this concern. Think about adding estimated manhours for installation, or weight factors to all details, so the designer, when selecting one, will pick the more economical type for the service intended.

We can now see that the drawings are becoming more compact, simple, and easily read, but for whom are we developing the drawings?

In the past, with the large deck and shell drawings, and most pieces being fabricated on the building ways, the conventional drawing practice was adequate. With photo lofting, the method may have merit, but with the use of numerical control burning equipment it is a whole new ball game. Most design offices do not play the game. The numerical control burning equipment should be as important to the designer as to the shipfitter. He should consider it in everything he does. Just think of the major changes in a design office and when the Iast one took place in yours, such as simplified drafting. That was nearly 20 years ago. The drawings are to a scale of 1/4, 3/8, 1/2= 1‘- 0”, or some other similar scale. Think of the advance in your shipyard if drawings could be made on a scale of 1/20, with all dimensions in hundredths of an inch, similar to numerically .controlled programs. The foundation of ship design will not crack if the 72” rule is broken. Do not allow designer the right to use the word “equal” when a number of structural members are similar, but require a true dimension. The parts programmers would have a lot less work and the possibility of error would be reduced. Drawing a simple overlay could check most parts by means of the parts programmer with the use of 1/20 scale plots. The designer should not be allowed to inndicate structure unless he defines it in detail. With this type of system, the designer, parts programmer, and fabricator will be as one, The design office will then function as a unit of the shipyard responsible for the complete detail design. In cases where a dimension does not require an exact length, then let it be known, as most yards accept a size as exact. See Figure 3.

It would be easier to make the change to the metric system from this concept because we have utilized the design by inches and decimals of an inch, we now have found the method to convert the detailing process to a computer data base, and this should be the ultimate goal of every shipyard. The straight conversion of a manual design method to a computer base has not, and will not, be easy. The years of designing ships have worn a rut in the brain of the designers’ because he thinks in the concept of total ships: Deck, shells, platforms, bulkhead, bulwarks, superstructure, main longitudinal bulkheads, keel; and the list goes on. Let us try to break this down into groups and subgroups. All ship structure is made-up of plates and shapes. All plates are either flat or curved, all shapes are rolled, extruded, or built-up members. This makes the programming a lot easier if we limit this basic consideration to these few types. Other general observations are that structural shapes are usually cut on the ends except for limbers, vent and drain holes with the exception of transverse members. When work-studying the assembly method this is ideal, as one or two layout men can cut every stiffener on an assemblyThis is very effective because all details are in a standard detailing book, and the details are similar and easy to cut.

The Navy and MARAD have looked at the possibility of a system based on these considerations. The system must have all the basic requirements of an up-to-date production tool for the shipbuilder. It is safe to say the shipbuilders in this country find it hard to develop interest in this approach, as it would require a change that may be too great

to take at once, and the Government, has not offered any special funding to help initiate the Change. Also shipyards are suspect of Government developed systems as they may invoke. controls over the builder. On the Government side, the idea of claims is always present when invoking a Government developed system.

Before we describe a possible computer System, let us first warn the reader of the implementations of a system that puts the responsibility of an entire ship construction,in the hands of a few people. There can be little or no deviation from the way the database is generated as each piece is tied into a control system. This also puts the responsibility of the design squarely on the shoulders of the designer, and his errors could be costly, The checks and balances of a complete system must allow a constant interplay between man and machine. Graphics are a visual aid but computer prinout listings must be checked. To expedite the availability of graphic drawings the shipyard has to be standardized for construction. Eliminate the frills of the past, this includes fancy title blocks, lists of unnecessary references, borders, numerous .unneeded sections of various scales, underlining, extensive notes, and unnecessary signatures of people who do not look at the drawing. All these may be n-ceded under the present system, but with a computer system the information will be in specific reports, and only be highlighted in the graphics.

New high speed plotters can produce deck and shell graphics to any scale required. This gives the design office their graphics, to the scale they wish, and production people will use 1/20 to check their numerically controlled work.

The system must start in the conceptual design phase if we are to develop a complete system. We cannot lose sight of the requirement of good design methods. In the past, the problem of design assisting production was timing and data preparation.

The need for a complete data base in the design area is very criticaI as we cannot check for all problems unless we know how to research them. When we talk of a complete system we should really understand the nature of the system. It need only be complete for the work intended. Also, we must realize that a total system has a great deal of man interface, not the. concept of push the button and out comes your ship.

All computer programs that are used today have one general short-coming, and that is data prepatation. Engineers do not want to draw. Even computer graphics generally turn them off. Designers don’t like computer graphics as the first few outputs are poor at best. They feel the manual method would be better. The parts programmer also has highs and lows in his work. He may specialize in an area that does not present a sound challenge. A complete system would help alll individuals and only special parts. would be worked on by various groups.

When a ship is under design development, number of specific areas are working at the same time. Hydrodynamics is developing the hull form, the, Arrangement section is locating the decks and transverse bulkheads, and Stability is checking the stability requirements for the various configurations. The structural engineer is working UP his longitudinal structure requirements. With the present day manual method, these are all independent actions. The database approach allows for a complete change.

The hydrodynamicist is developing a set of lines in the computer. This could be no more than the first or second input of basic control lines, He could at that time estimate the height, sheer, and camber of the weather deck. Each control line is assigned an identifier. The arrangement and structural sections can take these preliminary lines and start their own process. By keying into the original identifier, the three sections use fines that move as one, when the lines shift during development. The hydrodyamicist may call a specific we a waterline, and the arrangement and structured system would call that waterline an internal deck line. A buttock line may be a longitudinal bulkhead.

As stated, most people do not like to prepare data for only one purpose. In this regard the structural engineer enjoys structural design but no other discipline cares if he spends an hour, a day, a week, or month, on a specific area. Other disciplines are only interested in its impact on their area. The use of the structural design tool to assist in graphic output could be the salvation of a sound integrated system. Let us assume that we have the body Plan Of a typical ship, and a computer program to develop a midship or other longitudinal structure at various sections of **a** ship. The Navy has such a system called Structural Synthesis Design Program (SSDP). This system allows the engineer to input the location of major longitudinal surfaces such as shell, decks, longitudinal bulkheads and loading conditions, along with average longitudinal stiffener spacing, and the system will define. the necessary plating thickness and Longitudinal structure based on the loads and geometry input. By interfacing this with a computer drafting Program the engineer can establish data points for various surfaces wihout major data preparation. Manual interface is required to string these various sections, together via a structural body plan and shell expansion. For this the engineer will be specific in his locations and drop off of various members. He now fits this data back into SSDP and doubles the number of sections. This allows a design tool to direct a drafting tool, SSDP output is fed into two files, a line file that defines the location of the structure and a scantling file to give the thickness or size for both plates and shapes. MARAD is presently considering the further development of SSDP to include ships designed to American Bureau of Ships Standards.

With the use of identifiers in lieu of specific locations we are allowing the various components of the system the flexibility to develop their specific expertise and still interface with the originator of the data point. This technique is most important to all disciplines of ship design development and construction, with the cognizant department, code/section having the proper responsibility.

We have deviated so much from past practice, let us recap a little. The Hydrodynamic group is responsible for the hull development and appendages to the shell, the Arrangement section is responsible for location of all decks, platforms, flats and levels and in conjunction with Stability are responsible for all major structural bulkheads. The Arrangement section is also responsible for the location of all major and minor openings and miscellaneous structure and joiner work. The Structural section is responsible for all major and minor structure, including girders, longitudinals, stanchions, and transverse members. With the various discipline defined, we see that everyone can extract information from the cognizant code while inputting their own information.

We will limit further discussion to just structures. The responsibility of the structural engineer is to design for both primary and secondary loading conditions and to provide a structural arrangement that is compatible with the needs of the overall ship operation.

The structural engineer continues to tune the design and the other sections use his output by going to a cross index file to look up information they may wish to extract. Arrangements may call for all stanchions, and they will be shown as pipe or shapes at specific locations. The location of web frames, stanchions, and girders is important to various departments for their specific needs.

The structural engineer will periodically call up a simple graphic plot of all openings to check for locations. In the early design phase, when openings move often, indication of openings with the area still plated in will save a great deal of time.

When the design manager calls for a drawing review, or circulation, the various sections would not be affected. The data base would reflect the latest thinking, and graphic outputs could be extracted for the various drawings in a timely fashion. Compared to today’s method, where each section loses use of the. tracing for an extended period of

time, this would not be the case in a controlled system. The design manager would have a setup supplied by the various sections that would allow him to extract the needed data for his drawings to meet circulation dates.

We can now assume that the ship has gone through feasibility, conceptual, preliminary and contract design stages. The qualified shipbuilders are brought on board to familiarze them as to the special features of the design, and also to learn the details of structure available in the data base.

The result of this effort is a set of contract and contract guidance drawings. More important, it is a complete data base of all major structure; and a bill of material by plate thickness, square foot area, stiffener size and total length. A close survey of ships designed by the Navy has indicated that 85% of the plates and shapes indicated on the contract and contract guidance drawings, are actually used for construction of the ship,

When the system is first being used it will require a training period for the varvious skip design offices. The use of an identifier to replace the historical ship terms may ,seem difficult at first, but should be easily understood, as the identifiers are usually functional abbreviations of the various components. Examples - SH (Shell), DK (Deck), PF (platform), WI(waterline), PL (Plate), PC (Piece), ST (Stiffener), WF (Web Frame).

The output from the data base is the standard deck, shell, and bulkhead drawings, with some expansion. The deck drawings will include both port and starboard. The shell drawing will indicate both port and starboard shells and can both face the same way with hidden lines for members on the starboard and solid lines on the port view. The transverse bulkheads drawing will cover all bulkheads. The web frames and possibly some of the transverse bulkheads could be produced on a printer to reduce plot time. A complete bill of material will be available. The contractor will introduce master butts and have a preliminary cut at assemblies. The bill of material would be rerun and divided by assemblies. Care should be taken to insure that this division will be close to an acceptable erection approach, as the responsibility is changing hands from the contract design phase to the working drawing phase.

When the shipbuilder has accepted the contract package, the data base will be copied and provided for his design office. In general, the detail design is basically a process of expanding or detailing specific parts with a limited amount of original engineering. Most Navy contracts have all the design criteria in the detail specifications but most yards spot check the original contract design and concentrate on the areas not covered, such as main machinery, foundations and general foundations. Miscellaneous bulkheads are usually copies of adjoining structural bulkheads and trunks.

The design office can now assist the construction people in the definition of the ship by simply suppressing the sizes of various members. They will also supply complete layouts of various assemblies, not only by surfaces, but with isometric views for easier interpretation. The first setup will take a litte time and could be accomplished during negotiations. The following efforts would only require a reshuffle of data. This is the first step in design assisting construction with many more to follow.

At this time, the hull is finalized into asemblies and each assembly leader in design has his own data base. The steps from this point on are very similar to the assembly approach described in the manual method, with a few' exceptions. Progress can be measured based on the number of computer runs that are made. This really gives management a tool to work with as the costs are easy to assess and the progress can be measured. It is a very competitive way to work with teams trying to complete their assembly and most employees taking on a new interest. Once a team is established, their weakness and strength can be realized quickly and added training will correct the weakness. If for some reason a major change is made such as a modification to the combat suit, the ease of controlling a change can be readily realized.

The various assemblies could easily be merged together and produce the old reliable as-built drawings without much difficulty. The suppression and proper orientation of the various surfaces in a file, plotted out with a new up-dated data base, would give the owner of the ship a complete file of drawings for his ship. If the follow ships were awarded to another shipbuilder he could decide if the existing design would suit his special needs and the lead builder would not be responsible for the changes. This allows everyone to do their own thing and should give the owners duplication of ships.

The first thing a team leader should do is locate all major openings, or fixed openings, and introduce the neces-sary butts and seams for any known insert plate or changes in plate thickness. This could supply them a plate bill of material. The bill of material will be in several forms, for different reasons this is unlike the manual method. one by surface in an assembly, such as, all the plates on a deck. A separate listing by plate thickness and a comparison document could be a series of graphics of the pieces, in bounding rectangles to reduce waste. This is important to allow for close ordering of material and establish the preliminary nesting for numerically controlled burning. The nesting process starts before the material is ordered. With the use of local coordinates the nesting method is established for major plates. Only the remainder of the ordered plate is still available for small or miscellaneous pieces not yet defined.

In small yards, or yards with limited material handling or crane capabilities, it may be better to order by assem-blies so several ship sets can be ordered as they are to be used. Management has a tool to evaluate the problems asso-ciated with volume ordering based on construction needs,

The next step is upgrading the numerous scantlings on the various surfaces of the assembly. This includes ex-truded, rolled, built-up members, plate beams and stanchions. me method of input into the database is defined as stiffener members including both sizes of a ship. This is similar to the standard numbering of longitudinals on the deck from the centerline out, and on the shell from the keel up, both port and starboard. The size is given, and the members scantling size must be in the library of shapes available, with the overall length checked by the designer. The identifier is given as a surface identification. The distance from the forward perpendicular for the start and finish of each piece also lists all surfaces that are penetrated. The system will take it from there and make all neces-sary cutouts, order necessary collar plates, chocks, lugs or other minor structure. The system will locate a butt or seam that crosses the member and introduces a limber opening. A major problem in a computer system is a molded surface and the necessary modifications to a plate or shape that has a thickness of material on the other side of an abutting structure. What type of output should be available from this data?

The review of a structural working drawing takes time. The amount of study that presently goes on in a ship-yard is unaccountable because no one admit to the time it took to clarify just what the designer intended. In many cases, the worker may not be able to read a typical blueprint. When we consider a computer system, blueprint reading is not necessary.

With the central data base the job is so much easier. Let us think of the various steps and consider what would be of help. In cutting plate pieces, all pieces that are true rectangles should be known and the number of each speci-fic size noted. This could be listed and will then constitute a family of parts. If the ship builder has a heavy duty shear, he could elect to cut them this way and let the transverse frames and bulkheads locate the longitudinal stiffener on the structure, if edge proporation for welding was not a requirement.

The use of simple assembly graphic drawings is to show the cross association of plate pieces and their identifiers with the weld sequence required. This type of graphic is presently not in use in shipyards today. To these simple graphics, the welding engineer could indicate the weld sequences. In many yards today, the proper weld sequence is

poorly defined and a lot of cutting and refit work is done. The-reason is that a weld sequence drawing is high in cost and time consuming, and the amount of rework repair is unknown and most yards would like to think it is worth the chance. Poor planning is nearly as good as no planning.

The possibility of supplying-graphic drawings of each surface in the same view or plane as the surface which is being constructed would make the shipfitters fabrication easier. When various surfaces are joined, only simple graphics are required to detail connection points. The use of one complex drawing to cover the entire ship is poor at best. The increase in paper may be a concern but in many cases the individual drawing could be produced on a printer or small scale graphic plotter with a detail listing of the parts, the amount of various welds, the type of electrode. Now, instead of a piece number for each piece, the surface is the piece identifier. Controlled planning would allow for shipping, handling, and schedule requirements including inspection.

The butt welders don't care about the fillet welding and the other parameters necessary for other trades, so there is no need to tell him. For the yards that have panel welds, the program could search for the number of similar plate and stiffener pieces and a setup would be made. Even the different lengths could be part of the family of parts.

A study of the yard should be made to see if the openings should be left attached, with a bridge, to improve production by reducing special cases in construction. The hole would already be cut, the yard could wait till later to open up the piece. Distortion would be reduced, thereby, getting more use from the panel welder. In aluminum constrution this would have a lot of merit.

The study of how to handle stiffeners is a very important subject. The first listing to be printed is the stiffener bill of material (BOM). At the present time, the plate or built-up members will be covered in the plate bill of material, and a supplemental plate BOM is required to pick Up these pieces. The stiffener bill of material could have a standard format be adjusted, as required, by a shipbuilder and even print out his indicated sizes under **his** letterhead. The stiffener BOM will come in stiffener pieces identified by surface in an assembly. See Figure 4.

Summary: B/M similar to the plate BOM. The other report is by various stiffeners. Stiffeners are available in orderable lengths of 20,30, and 40 feet. The program reviews the number of lengths to cut the right number of pieces, and gives the number of pieces, the percentage of waste by lengths, and also by total of lengths. See Figure 5.

A review of the previous figures show that the System works on a six character identifier, with all Unnecessary zeros suppressed, that makes for easy readirig. If a directory of identifiers and equivalent ship terms is available on the graphic drawing or a small notebook for everyone to carry around, it would make it easier for most production people.

The cost of any computer program is commensurate with the data processed. To reduce cost a system of mirror images should be available and along with adjustments in programs, port and starboard identifiers can be produced. For cargo or tanker ships this is fine, but for combatants, it may be a waste of time.

Up to this point, we have defined the hull form, the plated areas, the shell, decks and bulkheads, and the extent of both longitudinal and transverse shapes that cross the major hull surfaces. We have been able to order the plate pieces and stiffeners. Also by this time, most numerical control tapes could be generated. **This** is different than the part programming method, as the numerically controlled graphics are produced from the data base before the tapes are generated. A listing of each tape is available and this is done by use of a post processor for a specific

type of numerically controlled equipment. A review of the graphics on individual pieces is made and the bill of material graphics for nested plates is checked. The location of bridges between pieces is picked. Those pieces involved are set out in a file, the necessary bridges made then stored in the data base.

The system should take each numerically controlled tape listing and run it through an optimization program that reduces the dead travel time and produces anew graphic. It indicates the piece ID, all punch marking and burning and also notes the amount of fast and slow travel in inches. This will allow for better scheduling of numerically controlled burning time. By adding the amounts against the thickness of the plate to be burned, management can determine if a specific task can be done by one shift with some overtime, or if two shifts will be required. This could be programmed to print out that information as a management tool. When numerically controlled burning has reached complete acceptance, the possibility of having numerically controlled machines at steel mills, and only shipping finished plates with punched ID's, could really save money. This may be a reality if pursued. Also, if a plate requires rolling, it could be noted and scheduled first as this would help the critical path.

The majority of computer systems are developed to cut plates using numerically controlled tapes that also punch mark the location of structural members. Definition of the structural member is done in the steel fabrication area or laid out in a loft or shop planning office and in most cases by hand.

A review was made on a LNG Carrier of 22,600 Long Tons, (LT) and a Barge Carrier of 14,000 LT. Figures list the quantities of various details and the hours required for layout, loft, cut or burn, fitup, installation, welding, inspections and handling for details. This requires a significant percentage of all hull steel fabrication and erection cost. If the actual percent of shipbuilding hours were available the amount would be quite high. See Figure 6.

We have talked about various aspects of a system and now we must talk about structural details. The concern of structural details should be considered as the heart of structural design. Poor detail at a critical location has, in most cases, been the primary source of structural failure. Without proper attention in the design office, poor details can creep into a design without the knowledge of responsible parties. This can happen from lack of specific detailing for each intersection point or assembly. The responsibly of detailing may fall on the shipfitter level if the design office has not assumed the proper responsibility. A notch, rough cut, misalignment, poor welding or undefined erection sequence may cause a failure. A good QA program in support of a good design can protect the ship against the design problem by incorporation of standard details. A detail is the joint or point on a surface where an "event" occurs. The events can include a member ending on another structure, or a member penetrating a deeper member. The variations of these samples are many. With the addition of brackets, chhocks and collar plates, the detail becomes complex. The system should have a method of inspecting the detail point by cross association of members and plate surfaces. This is the expensive part of construction and of a computer system, because many checks must be made, From this cross association of plate surfaces and number pieces the following information is available, first, from an assembly point of view, then from a detail point.

1) The end cuts of members are defined.

2) The location of, and quantity of, minor structure is available; a chocks, brackets, lugs, sole plates and collars, and also the type of watertight nontight, flush or lapped collars. This gives the planner a very good tool as he finally has a count of each type of part within an assembly, and in some cases, he may find only one of a given size and shape, then hundreds of another. The miscellaneous minor structure can be cut from the surplus from nested plates or because the number may be cut from large specially ordered plates. Also, another review can be made of special thicknesses, which could be rounded off to available material, when a slight weight increase is acceptable.

The library of details is very importants. Using the surface identifier, the system can control the use of a detail. If a specific configuration is not in the library, the system will print a note indicating that the detail is not implemented. This gives the designer a chance to review the structural configuration and decide if a change in associated structure or implementation of the detail is necessary. This is extremely important in ships that are weight critical, especially in aluminum hulls, as steel detail is not always acceptable for aluminum construction. Much more care is required at detail points, and transition pieces are criticaI. When working with alnminum, the builder finds the material is less forgiving than steel.

We have taken the information and developed a stiffener fabrication report that tells just how to cut the stiffener not only at the ends but along the web of the member. The location of the minor structure that is required and also a bending template if required. This data could be programmed to fit bending machine, when available.

We have a way of cutting each stiffener in an assembly. It is a good move, but we now need to develop a system of mass production. An evaluation earlier noted that the majority of members are cut only on the end. This allows the system to check the data base and sort alI similar size members with identifiable end cuts, even though the length varies, and to group them in order of length. See Figure 7. This is a good use of group technology as We are deveIopoing a fmily of parts. We also may have some stiffeners with additionrd cuts and bending required. The system identifies the page of the report which describes specific interior cuts or bending. This is the step that superceded the capability to check the random lengths of the bill of materials based on orderable lengths. The program could be run and the material waste calculated in a production mode. With this summary listing, the system could produce a series of labels in the same order as the stiffeners are cut. This would identify the member with ease. For aluminum hulls, this system is ideal. In steel hulls, the procedure is good only if the material is not left loose or exposed to the weather for a long period of time.

Capabilities that could be made available is a report of the length of weld to specifically note the amount of each type or size of weld by piece, surface or assembly. This would assist in establishing critical path and manpower requirements.

In conclusion, it must be noted that any design office can make a serious inroad into the production method of their shipyard, and still prepare designs with the same amount of manhours or less. If and when a yard is ready to introduce computer generated data for construction in a serious, way, management must realize that the designer will be the single source of information.

Management will realize a sizable reduction in the number of people in design costs, weight control costs, mold loft costs, and planning. The disadvantage is the power a system like this will leave in the hands of a few. Sound shipbuilding people are getting harder to find.

In a limited market the good will rise and if the money is not right, will move. If only shipbuilding was like sex and could be learned over night! A serious problem in todays shipyards is who should receive what drawings, scheduling, planning documents and general pieces of paper. In the computer system the documents would be developed for a certain need and limit the number of people that would receive the information.

Production people will accept the change much more readily than the design office. The design office will find problems as the computer has no judgement factor that will correct misinformation. The change will be made at some time especially if other countries try and have success.

Just let your mind run and realize that the proposed system is nearly avaiIable. The follow-on from this is a similar approach to develop the following:

1. Joiner bulkheads with all associated pieces listed and defined.

2. Door, hatch and scuttle lists.

3. Key lists.

4. Insulation drawings and material lists.

5. Paint schedule and material ordering list based on thickness and square footage.

6. Deck covering schedule.

7. And from your own experience you could add many more.

The cost of material and labor demands a central system as the manual method is costly. The scheduling of unknowns based on poor guesses is one of the main reasons for poor shipyard schedules.

Using the assembly approach, the amount of welding wire, staging, and amount of outfitting will be better controlled. Present day unknowns will have more traceability and everyone will have a better handle on their part of the job.

The assembly approach would allow for a more accurate method of progress payments. The cash flow problem will be better than controlled. In times of need, high cost assemblies could be fabricated and assist in getting the buiIder the money required to meet cash flow problems.

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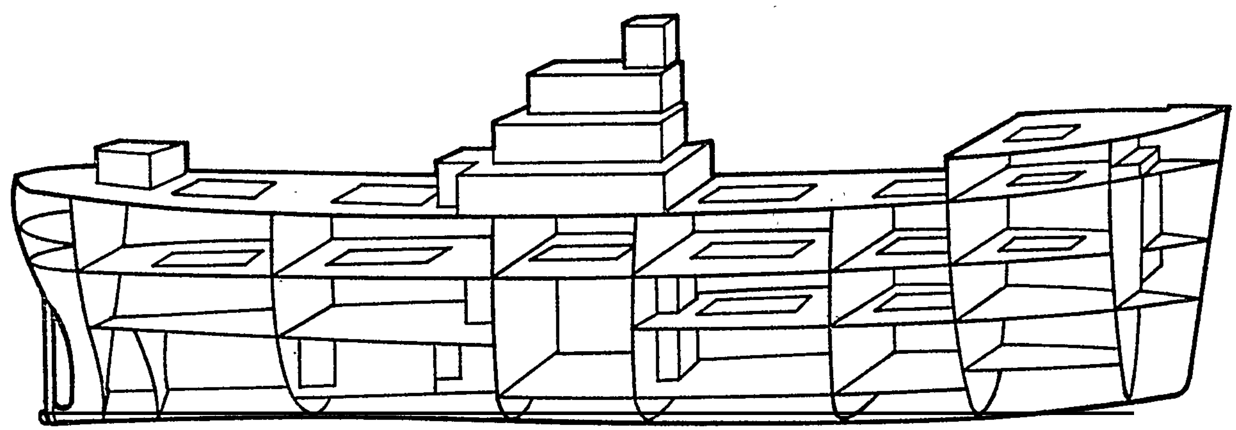
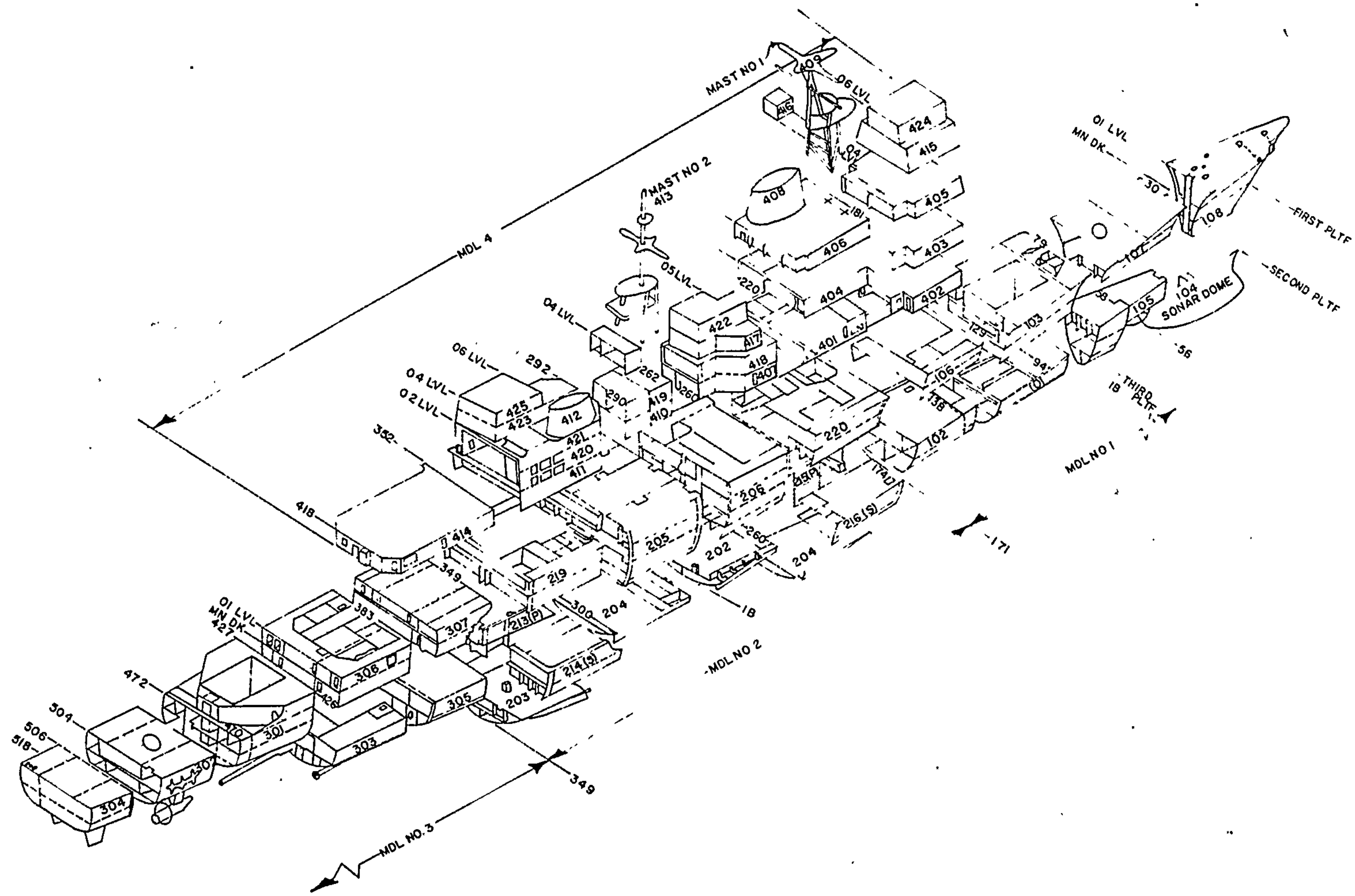


FIGURE 1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06 LVL
MAST NO 2
413
MDL 4
05 LVL
04 LVL
06 LVL
04 LVL
02 LVL
01 LVL
MN DK
FIRST PLTF
SECOND PLTF
THIRD PLTF
SONAR DOME
MDL NO 1
MDL NO 2
MDL NO. 3
01 LVL
MN DK
424
415
405
406
403
404
402
401
422
417
418
425
423
412
420
411
414
408
409
220
205
206
202
204
219
307
306
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106
18
171
56

FIGURE 2

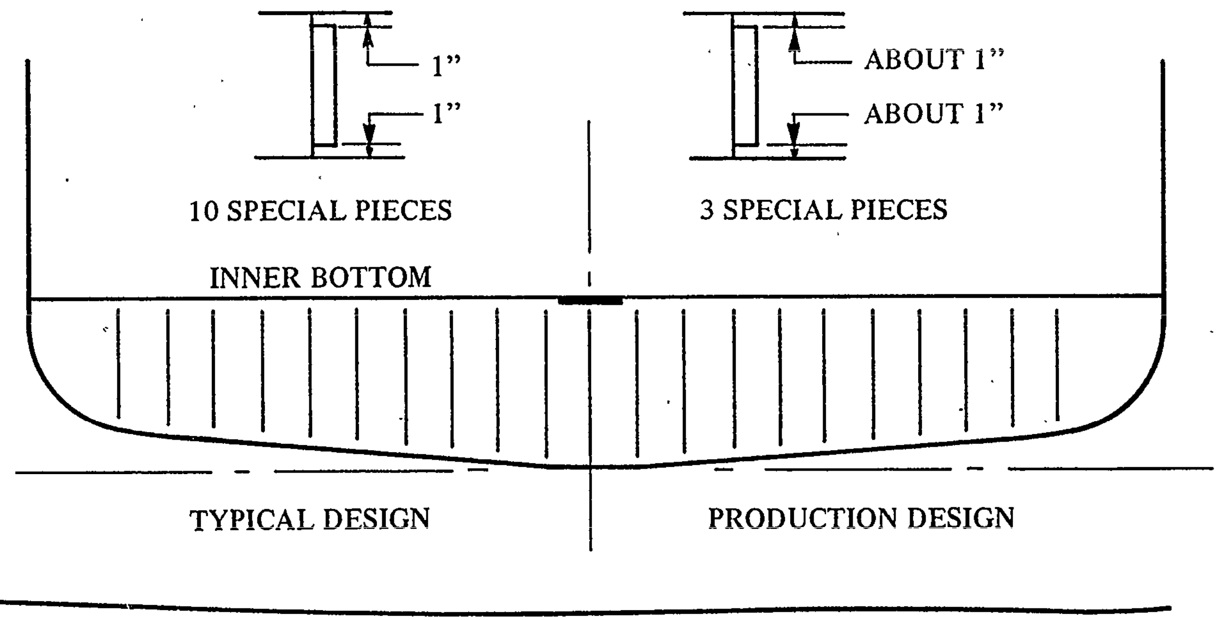

1"
1"
ABOUT 1"
ABOUT 1"
10 SPECIAL PIECES
3 SPECIAL PIECES
INNER BOTTOM
TYPICAL DESIGN
PRODUCTION DESIGN

FIGURE 3

SURFACE	STIFFENER ID	SCANTLINGS	METAL	LENGTH	WEIGHT (LBS)
SHS	WF0750 PCO012	10 X53/4X25.001-T	MS	6-02-02	106.30
SHS	GRSOOO PCOO03	14X8X48.001-T "	MS	5-09-07	190.86
sHS	STSO1O PCOOO1	4X4X5.00T	**MS**	23-10-11	120.23
SHS	STS020 PCOO02	4X4X5.00T	MS	Z3-IQ-06	120.10
SHS	STS040 PCOO04	4X4X5.00T	MS	15-03-04	76.85
SHS	STS050 PCOO05	4X4X5.00T	MS	15-02-03	76.40
SHS	STS060 PCOO07	4X4X5.00T	MS	15-06-02	78.05
SHS	STS060 PCOO08	4X4X5.00T	**MS**	3-07-02	18.09
SHS	STS080 PCOO09	4X4X5.00T	MS	5-03-03	26.50
SHS	STS11O PCOO1O	4X4X5.00T .	MS	24-06-05	123.43
SHS	STSIZO PCOO1I	4X4X5.00T	MS	24.06-01	123.32
SHS	STS070 PCOO08	4X4X5.00T	MS	15.00-13	75.82

I *STIFFENER WEIGHT FOR THIS SURFACE –1135.96LBS

TB665	PST025	4X4X5.00T	MS	60O-10	30.46
T8665	PST026	4X4X5.00T	MS	6-06-10	32.98
TB665	PST027	4X4X5.00T	MS	6-10.04	34.48
TB665	PST028	4X4X5.00T	MS	6-11.06	34.96
TB665	PST029	4X4X5.00T	MS	7-03-09	36.72
TB665	PST030	4X4X5.00T	MS	7-03-10	36.76
T8665	PST031	4X4X5.00T	MS	7-03-10	36.76-
TB665	PST032	4X4X5.00T	MS	7-03-09	36.72
TB665	PST033	4X4X5.00T	MS	3-06-10	17.87
TB665	PST034	4X4X5.00T	MS	4-03-00	21.40
TB665	PST035	4X4X5.00T	**MS**	3-05-06	17.34
TB665	PST036	4X4X5.00T	MS	6-10-04	34.48
T8665	PST037	4X4X5.00T	MS	6-06-10	32.98
TB665	PST038	4X4X5.00T	MS,	6-00-10	30.46.

****STIFFENER WEIGHT FOR THIS SURFACE – 434.35 LBS**
****TOTAL STIFFENER WEIGHT FOR THIS**
ASSEMBLY –4423.29 LBS

STIFFENER BILL OF MATERIAL BY SURFACE

SURFACE ISALPHABETICAL
STIFFENER LENGTH SHQWN IN FT-IN-16THS

SHIP-
ASSY- SA5
10/22/ PAGE: 2

FIGURE 4

QUANTITY	SCANTLINGS	LENGTH	SURFACE	STIFFENER I.D.	LENGTHS IN FT 20	30	40	PERCENT OF WASTE 20	30	40
1	4X4X5.00T	3-05-06	TB665	PST035	*	*	*	*	*	*
1	4X4X5.00T	3-06-10	TB665	PST033	*	*	*	*	*	*
1	4X4X5.00T	3-07-02	SHS	STS060 P08	*	*	*	*	*	*
1	4X4X5.00T	4-03-00	TB665	PST034	*	*	*	*	*	*
1	4X4X5.00T	4-09-13	LBST35	PST006	1	*	*	1.7	*	*
1	4X4X5.00T	5-03-03	SHS	STS080 P09	*	1	*	*	16.9	*
2	4X4X5.00T	6-00-10	TB665	PST025	*	*	*	*	*	*
	4X4X5.00T	6-00-10	TB665	PST038	1	*	1	13.1	*	7.4
2	4X4X5.00T	6-06-10	TB665	PST026	*	*	*	*	*	*
	4X4X5.00T	6-06-10	TB665	PST037	*	1	*	*	16.0	*
1	4X4X5.00T	6-08-02	LBST3S	PST007	1	*	*	1.1	*	*
2	4X4X5.00T	6-10-04	TB665	PST027	*	*	*	*	*	*
	4X4X5.00T	6-10-04	TB665	PST036	1	*	1	31.5	*	16.3
1	4X4X5.00T	6-11-06	TB665	PST028	*	1	*	*	8.9	*
1	4X4X5.00T	7-00-02	LBST3S	PSL008	1	*	*	30.2	*	*
1	4X4X5.00T	7-02-14	LBST3S	PSL009	*	*	*	*	*	*
2	4X4X5.00T	7-03-09	TB665	PST029	1	*	*	27.3	*	*
	4X4X5.00T	7-03-09	TB665	PST032	*	1	1	*	3.8	10.5
2	4X4X5.00T	7-03-10	TB665	PST030	1	*	*	27.0	*	*
	4X4X5.00T	7-03-10	TB665	PST031	*	*	*	*	*	*
1	4X4X5.00T	7-05-08	LBST3S	PSL010	1	1	*	26.2	26.4	*
1	4X4X5.00T	15-00-13	SHS	STS070 P06	1	1	1	24.7	49.8	7.2
1	4X4X5.00T	15-02-3	SHS	STS050 P05	1	1	*	24.1	49.4	*
1	4X4X5.00T	15-03-04	SHS	STS040 P04	1	1	1	23.6	49.1	23.9
1	4X4X5.00T	15-06-02	SHS	STS060 P07	1	1	*	22.4	48.3	*
1	4X4X5.00T	23-10-06	SHS	STS020 P02	NA	1	1	NA	20.4	1.6
1	4X4X5.00T	23-10-11	SHS	STS010 P01	NA	1	1	NA	20.4	40.3
1	4X4X5.00T	24-06-01	SHS	STS120 P011	NA	1	1	NA	18.3	38.7
1	4X4X5.00T	24-06-05	SHS	STS110 P010	NA	1	1	NA	18.2	38.7

LENGTH	X	NO. OF PIECES	X WEIGHT	= TOTAL WEIGHT	TOTAL CUT LENGTH	TOTAL PERCENT WASTE
20 FT	X	NA	X 5.032	= NA	NA	NA
30 FT	X	13	X 5.032	= 1952.480	286.215 FT	26.5
40 FT	X	9	X 5.032	= 1811.520	286.215 FT	20.5

STIFFENER BILL OF MATERIAL
SUMMARY REPORT

*STIFFENER LENGTH SHOWN IN FT-IN-16THS
METAL TYPE – MS

SHIP-
ASSY- SA5
10/22/7 PAGE: 3

FIGURE 5

COUNT AND RANKING OF SHIP STRUCTURAL DETAILS

LNG CARRIER

RANK	TYPE – DESCRIPTION	TOTAL COUNT	TOTAL MANHOURS
1	Panel Stiffeners	11090	51835
2	Brackets	1330	14760
3	Scallops	20020	10605
4	Openings in Girders	12700	10510
5	Structural Intersections	4950	8640
6	Chocks	1180	5080
7	Tripping Brackets .	740	2530
8	Stanchion Support	190	2000
9	Stiffener Endings	1360	1180
10	Snipes	770	230
11	Mkcellaneous Cutouts	150	**7 0**

Total 170,440

BARGE CARRIER

1	Structural Intersection	22880	62910
2	Stiffener Endings – Chocks	11590	27125
3	Panel Stiffeners	7050	26455
4	Brackets	1200	4550
5	Tripping Brackets	250	3333
6	Openings in Girders	7370	3270
7	Stanchion Support	390	2700
8	Snipes	500	140
9	scallops	.200	90

Total 130,573

FIGURE 6

SUMMARY OF END CUTS

```
*********...********
*                  *
*                  *
*                  *
*                  *
*********...********
*********...********
```

ENDOO1 TYPE 7-01

NO CUTS

```
*********...********
*                  *
*                  *
*  ****  ...  **** *
*                  *
*                  *
*********...********
```

END002 TYPE 7-01

NO CUTS

***SCANTLINGS - 4x4x5.00T

STIFFENERS WITH ABOVE END CUTS

PAGE	QTY	LENGTH	SURFACE	STIFFENER
176	5	6-11-13	LBST7P	PSL029
174		6-11-13	LBST7P	PSL028
168		6-11-13	LBST6S	PSL042
166		6-11-13	LBST6S	PSL041
164		6-11-13	L8ST6S	PSL040
144	5	6-11-12	LBST4S	PSL015
142		6.11-12	LBST4S	PSL014
140		‘6-11-12	L8ST4S	P5LO13
130		6-1 1~12	LBST4P	PSLO09
128		6-11-12	L8ST4P	PSLO08
126		6-11-12	LBST4F	PSLO07

SUMMARY OF END CUTS
FOR ASSEMBLY – SAOO3 METAL TYPE – MS

FIGURE 7

SUMMARY OF END CUTS

```
S*******...*** C * S         *********...********
*                  *         *                  *
*                  *         *                  *
*                  *         *  ****  ...  **** *
*             .    *         *                  *
*********...********         *                  *
*********...********         *********...********
```

E00683 TYPE 8-01

NO CUTS

E00893 TYPE 8-01

NO CUTS

STIFFENERS WITH ABOVE END CUTS ****SCANTLINGS - 4X4X5.00T ****

PAGE	QTY	LENGTH	SURFACE	STIFFENER I.D.		
259	8	21-00-00	SH000S	STS100 P00009		*OTHER CUTS REQUIRED
265		21-00-00	SH000S	STS120 P00011		*OTHER CUTS REQUIRED
262		21-00-00	SH000S	STS110 P00010		*OTHER CUTS REQUIRED
246		21-00-00	SH000S	STS060 P00005	*BENDING REQUIRED	*OTHER CUTS REQUIRED
243		21-00-00	SH000S	STS050 P00004	*BENDING REQUIRED	*OTHER CUTS REQUIRED
240		21-00-00	SH000S	STS040 P00003	*BENDING REQUIRED	*OTHER CUTS REQUIRED
237		21-00-00	SH000S	STS020 P00002	*BENDING REQUIRED	*OTHER CUTS REQUIRED
234		21-00-00	SH000S	STS010 P00001	*BENDING REQUIRED	*OTHER CUTS REQUIRED

SUMMARY OF END CUTS
FOR ASSEMBLY – SA0003 METAL TYPE – MS

DATE:
PAGE: 382

FIGURE 8

AN APPROACH FOR THE USE OF INTERACTIVE GRAPHICS IN PART DEFINITION AND NESTING

Arthur F. Kaun
Newport News Shipbuilding and Dry Dock Company
Newport News, Virginia

Mr. Kaun is the production computer systems supervisor at NNSDD where he is currently responsible for the support of steel fabrication computer systems. This includes developing an interactive graphics approch to parts definition for Newport News in accordance with the MarAd funded project and the general support of AUTOKON and related computer systems.

Mr. Kaun has a degree in mathematics from the University of Michigan.

An Approach for Use of Interactive Graphics in Part Definition and Nesting

A year ago I spoke about the feasibility study we at Newport News were going to do-toward a mini based interactive graphics sysyem for parts definition. Here I am again, and anyone could justifiably ask - what have you done in a year? In fact we've been asked that question along with being complemented on inventing the best boondoggle at Newport News in recent memory. But it hasn't been that much fun - in fact it has been more like frustration trying to reach a bottom line. Today, I'd like to tell you some of the complexities connected with this project to show you why it-has been difficult to reach a final conclusion.

There are two major areas of complexity:

1. Project Constraints
2. Market place constraints

PROJECT CONSTRAINTS

1. Parts Definition Philosophy - There are numerious ways to define steel parts and each yard favors some subset of these. Interactive graphics is just one of these and not necessarily the obvious best choice right now. Those I know of are:

- Optical negatives
- Digitizing
- Part Coding
- Part Splitting
- Direct ESSI
- APT
- Interactive Graphics

1. (Continued)

The philosophy differences come in on whether interactive coding should be the best approach toward speeding the process, or perhaps using AUTOKON NORMS in a digitizing system or even letting the Design office put the parts in numerical form rather than the Mold Loft. We've also heard philosophy differenceson whether the source code or the part geometry itself should be kept as the true record of the part. In other words, Parts Definition is different things to different people.

2. MARAD Involvement - The details of the U.S. Government being involved in the procurement of hardware and software had to be explained to each vendor contacted. These details revolved around software improvements entering into the public domain, distribution rights of MARAD within REAPS and distribution of hardware and software within each shipyard for multiple systems. It would have been easy if only Newport News were buying the system, but it's a different story when you're talking about a system for possible use by multiple companies under the distributorship of the MARAD branch of the Federal Government.

3. Shipyard Size - When dealing with a number of shipyards, the question naturally arises - what can each justify in the area of interactive graphics? While some can justify a large mini computer configuration with numerous work stations, others will only be able to justify one work station and may want to connect it to an already existent mini or host comppter system. Some yards may not have enough volume of work to even considers new method of defining NC parts, and some will find that parts definition ranks low on a list of projects for which better returns on investment are available.

4. Autokon-Spades-Steerbear - These three shipbuilding systems are all similar in what they do, yet different in technique and data structure. A graphics part definition system would conceivably' have to interface to each. What is this interface, is it feasible and who will do it are all questions that will eventually have to be answered. Also, are the system philosophies of each so different that a graphics parts definition system couldn't serve as an exteniion of all three?

5. Portability - This has been one of the biggest constraints. With varying needs across yards, how do you satisfy all? If the final result is a system that ties hardware and software to gether, each yard desiring the system would have to procure the whole -thing - hardware and software; Or if a system is designed that results in general software, not tied tightly to minis or scopes, each yard' can mix and match it's own configuration and obtain the capabilities each 'wants for the desired investment. While this approach sounds good, it has some drawbacks. Due to its generality, it would have to become more of a general tool and less of a tailored shipbuilding package. Furthermore, there would be no common package within REAPS and thus no opportunity to share improvements and jointly develop new features for everyone's benefit. To provide this general, portable system might well require more work by REAPS to establish interfaces to varying options. And finally, portability can lead to inefficiency by not allowing the software to take full advantage of any specific hardware features.

6. Sophistication - Each yard varies in its level and need for sophistication. Computer analyst staffs to support such a system way vary from 2-150 people. While some yards have been involved in NC systems for many years and have evolved expertise, others are just starting out and couldn't support anything very sophisticated as yet.

7. Short vs. Long Term Considerations - Each yard must look at its immediate and long term needs in this area, of parts definition. Some need aids now, while others don't see a need for some time to come. These needs are heavily influenced by production cycles which create volume and deadlines. Other yards might be considering changes in their product lines.

8. Yard Policy/Direction - Who is the user of such a system - Mold Loft, Design, Engineering? Should the Lofts job of parts definition be merged into design or should it remain part of the production environment? Furthermore, will each yard make available to such a system the lines and surfaces of a ship as a reference in defining parts? If so, this calls for more 'interfaces and new techniques. Each yard should further be looking at other applications that a graphics system might satisfy - such as drafting hull design, piping, electrical, machining, etc. A graphics system can also aid in producing documentation such as detail, shop and assembly drawings. This documentation will vary from yard-to yard.

9. Accuracy - What is needed by the shipbuilding industry? We keep hearing horror stories about ships being built too long or too short due to computer roundoff errors. Accuracy ranges from 1,600 feet lengths accurate to .01 mm; to 100 feet coordinate systems accurate to 1 mm.

MARKET PLACE CONSTRAINS

1. Technology The interactive graphics industry is a relatively young industry with new companies continuously entering into it. Software is constantly being improved as more systems are installed and used in industry. The micro-processor and inexpensive memories have brought rapid changes in the mini-computer, scopes and controller areas, at the same time challenging the software to take advantage of these improvements.

1. (Continued)

In essence, one could conduct's never ending feasibility study, because as soon as one is ready to decide, something new and better will pop up to be investigated further.

2. Refresh vs. Storage Tube - These are two separate technologies within computer graphics, each having-their own advantages and disadvantages. One difference is the cost difference, however the cost of refresh is rapidly decreasing. Is refresh really needed in shipbuilding? For parts definition it appears helpful although not essential, however interactive nesting appears to be an application well suited for real time movement on the screen. Further more, from those we've talked to refresh appears to be the techrtology of the future and thus more desirable, if the price can be paid now.

3. General vs. Specific Software - One will find two types of software on the market. One type features the basic building blocks of descriptive geometry, leaving it to the user to build any application packages he desires. Another type is the final application software, the disadvantage of which is that the building blocks aren't necessarily obvious for the user to take and build yet other application software. It appears that one can't have both types, although such a combination would be ideal.

4. Components vs. Total - The easy approach is to buy a completely integrated system from one vendor, but this will cause portability problems for some of the REAPS yards. On the other hand if it is more desirable to buy the components separately (mini, scopes, software, etc.), then one has to become an expert in each of these areas in order to choose the best components for the final system. This may become more time consuming than desired at each yard. Furthermore, solving the interface problems between the components may be more complex then they first appear.

Mainframe vs. Stand Alone Minis - Some yards might have the desire to run graphics software on a mainframe computer instead of a mini. Is this possible? There are some doubts, due to the need of graphics to execute in real time and the mainframe's ability to provide such service. Other considerations are the priority given to graphics as compared to other shipyard applications and the CPU demand made by the graphics software itself. A shipyard that desires to have work stations located remotely from the mini or mainframe computers, may find it difficult to accomplish due to response requirements over communication lines. A user should also consider the costs of providing operators and hardware maintenance should they choose to go with a mini computer. Finally, when a yard asks how many work stations will a graphics system support, it will receive various and all too often vague answers, due mainly to the unknown impact that any given work station would generate at any time.

Benchmarks - Benchmarks are necessary to evalute qraphics systems, however they don't yield as quantitative a result as one may desire. Because each benchmark is run on different hardware/software combination, the results are different. Because vendors are asked to do things instead of run programs, they often vary in how completely they satisfy a benchmark. Some are very thorough, while others only take time to run through a canned demonstration. Slightly different results are also obtained when a refresh system is being compared to a storage tube system. Some vendors offer geometric building blocks and use them to perform the benchmark, while other vendors write specialized programs to satisfy the benchmark. So even through it is difficult to line up interactive graphics system for comparison, by running a comprehensive benchmark, the vendor does demonstrate most of the strengths and weaknesses of his system. The buyer must then evaluate which areas are of most importance in choosing a system.

Accuracy - As mentioned previously, accuracy is a requirement for a shipbuilding system. Many of the vendors visited were surprised to hear this, especially since they have not been required to provide more than 5-6 place accuracy before now. To obtain the 8 place accuracy we felt necessary, a 16 bit mini computer would have to store coordinates in double precision integer, which exists on few if any 16 bit minis, and perform calculations in double precision floating point which is often slow on such, a small computer. The additional core and disk storage requirements for double precision would also be a drawback. Some vendors were surprised to find out that the accuracy they claimed to have didn't really exist when benchmarks were run to tesrt it.

CONCLUSION

With all of the above constraints one could ask - "Is it an impossible task?" We don't think so. It is our desire to obtain a flexible tool that can then be developed into an effective shipbuilding system for use in this industry as a whole.

COMPUTERS IN SHIP DESIGN AND PRODUCTION: NECESSARY STEPS TO THE PAYOFF

Bernard M. Thomson
David W. Taylor Naval Ship-Research and Development Center
Bethesda, Maryland

Mr. Thomson is a naval architect and hull group leader in the Computer-Aided Design and Manufacturing Division. He is currently responsible for the development of the Hull Detail Design and Construction (HULDAC) system, that segment of the Navy's Computer-Aided Design and Construction (CASDAC) project which addresses detailed design and construction of hull components: structure, arrangements and outfitting.

Mr. Thomson has a B.S. degree in naval architecture and marine engineering, Webb Institute of Naval Architecture; an S.M. degree and Engineer's degree, both in naval architecture and marine engineering, M.I.T.; and an M.S. degree in management, George Washington University.

INTRODUCTION

During the last decade, numerically controlled (N/C) flame cutting systems have established themselves firmly as an integral part of the shipbuilding industry, but the computer software systems which have been developed to generate the N/C instructions prove to be a continually growing and expanding component of the' process. A number of such systems are commercially available, all vigorously developing new capabi.liti.es which are marketed as successive versions of the systems.

This paper cites directions of new development in a. number of the-leading systems and generalizes to identify several visible trends in the development of shipbuilding software. systems. These trends are explained in terms of the technical and economic mechanisms driving them. We should expect these trends to culminate in a new payoff of benefits distinct from the advantages which we currently realize from N/C processes.

The pathway from the present situation to the realization of this payoff contains pitfalls, however. This paper will attempt to illuminate one such hazard which has been 'underpublicized, which we can do something about, and which we must act on, now or the opportunity will be lost.

TRENDS

As in most businesses today, electronic data processi.ng (EDP) is well established in the administrative operation of shipyards; in this paper we are not primarily concerned with that usage of computing. In technical functions, programs have long been used for weight calculations, structural analysis, and a modest number of other isolated scientific tasks, but this usage has had a correspondingly modest impact on the ship design and construction process in our shipyards. The first major impact of the computer on the design/production shipyard operation has been to support N/C flame cutting.

N/C tapes were initially produced very laboriously using rudimentary parts programming languages. The effort of loading digital data to produce N/C tapes has subsequently been reduced with the development of more sophisticated parts programming languages, with the usage of "macros" and "norms," and by the technique of storing the hull molded surface one time and merely referencing it as necessary for position information respecting particular parts. Eventually algorithms were added to fair the hull surface and to assist in loading data respecting longitudinal stiffening into the data file, also to be referenced when defining parts. The original motivations for this aggregate parts programming capability were the reduced cost and increased dimensional

accuracy of automated manufacture, and the successive development of the capability has been driven by the need to reduce costs of the N/C input task. The ongoing extension of this trend in today's shipbuilding N/C systems is toward inclusion of capabilities explicitly for the design/engineering phase of the shipbuilding process. The continuing and apparently natural growth of computer impact is from the Production Department back up through the process into Design and Engineering.

Figure 1 cites some of the newer areas being emphasized in several of the principal shipbuilding computer systems. These development efforts are more fully described in references through 7. Although there is an apparent diversity of development emphasis, it will help us cope with this expanding field if we recognize and accept that the most significant trend in shipbuilding computer systems is their continual incorporation of additional functions.

Figure 2 represents this dominant trend as the phenomenon of increasing higher integration of these systems in five distinct dimensions.

We have already noted the extension of systems "up the process" in the direction of design/engineering, and more will be discussed on this later.

- We can see also the inclusion in the automated process of more parts of the ship structure, such as transverse structure and small structural parts (chocks, tripping brackets, sole plates, etc.), and one may reasonably extrapolate the trend to eventually encompass foundations.

- Some systems are beginning to integrate across design disciplines to facilitate coordination of piping, structure, and arrangements.

- There is a growing awareness of the need to integrate the technical data with data files for management and administrative functions (estimating, scheduling, progress reporting, procurement, etc.). In a landmark state-of-the-art survey of computer-aided design (CAD), Hatvany *et al* state:

  > The satisfactory solution to creating an efficient output interface for CAD in each case requires basic consideration of the integration of the entire design, manufacturing, and administrative process. Without this, only partial ad hoc solutions can be found. (Reference 8)

WORLIMIDE SHIPBUILDING COMPUTER SYSTEMS ARE EMPHASIZING NEW APPLICATIONS

- AUTOKON: OUTFITTING, STRUCTURAL DETAILING, STRUCTURAL ANALYSIS OPTIMIZATION, PIPING ARRANGEMENT, GENERAL-PURPOSE DRAFTING
- BRITISH SHIP RESEARCH ASSOCIATION, SHIP STRUCTURAL DESIGN SYSTEM (SSDS): INTEGRATION OF DESIGN AND PRODUCTION, CENTRAL DATA BASE, STANDARD STRUCTURAL DETAILS
- ITALCANTIERI, SCAFO SYSTEM & OTHERS: HIGHLY INTEGRATED SYSTEM OF STRUCTURAL & ARRANGEMENTS DESIGN PROGRAMS WITH MANUFACTURING & PROCUREMENT-ORIENTED SOFTWARE
- HITACHI, FNC SMALL SYSTEM: INCORPORATES SMALL STRUCTURAL PARTS INTO AUTOMATED PRODUCTION PROCESS
- KOCKUMS: INCORPORATING SMALL STRUCTURAL PARTS, EMPHASIZING PLANNING AND ADMINISTRATIVE FUNCTIONS
- SPADES: PRODUCTION PLANNING & SCHEDULING, STEEL MATERIAL CONTROL, STRUCTURAL DRAFTING, MORE POWERFUL STRUCTURAL DATA LOADING

FIGURE 1

THE MOST SIGNIFICANT TREND IN SHIPBUILDING COMPUTER SYSTEMS IS THEIR CONTINUAL INCORPORATION OF ADDITIONAL FUNCTIONS,

THIS TREND MAY BE CHARACTERIZED AS INCREASING HIGHER INTEGRATION IN 5 DIMENSIONS:

THROUGHT THE-SHIP DESIGN/PRODUCTION PROCESS

INCORPORATING MORE 0F SHIP STRUCTURE

ACROSS 'DESIGN DISCIPLINES

WITH ADMINISTRATIVE FUNCTIONS

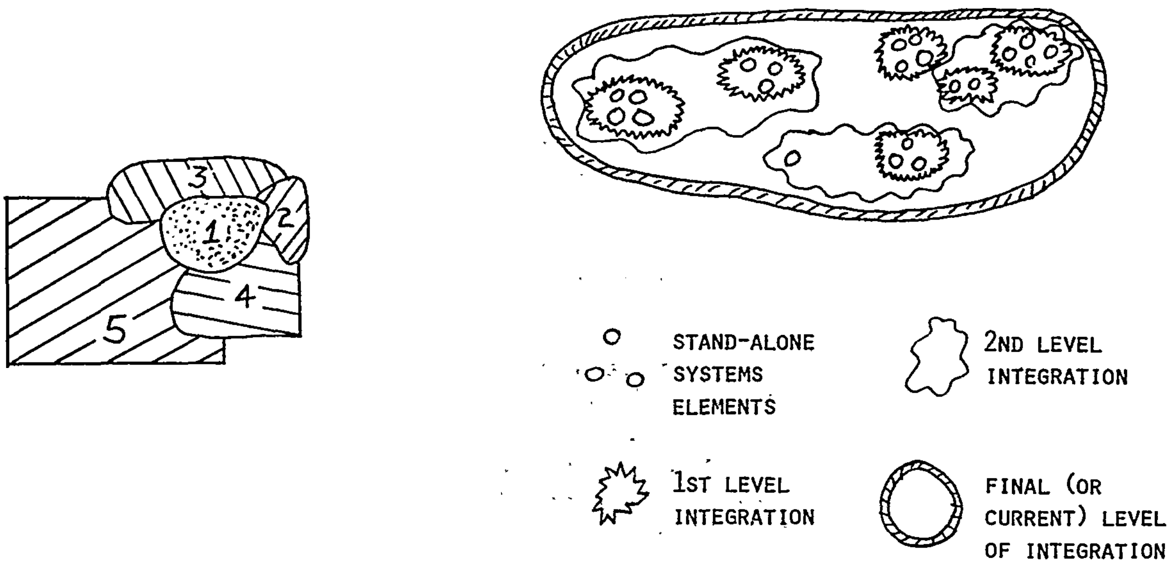
WITH OTHER ORGANIZATIONS IN INDUSTRY

FIGURE 2

- Finally, the high cost of developing and maintaining these increasingly complex systems is demanding that users pool their resources with other industry organizations, thereby requiring and establishing a level of integration across corporate lines.

In the growth of shipbuilding computer systems, we can observe two forms of accumulative integration, as depicted in Figure 3. Tangential integration, wherein one original “core” program’ is successively expanded to encompass additional adjacent tasks, is perhaps best representative of our overall trend. Often, however, two programs begun independently grow together as one or both incorporate functions which link them. We can refer to this clustering phenomenon as hierarchical integration, because it often occurs recursively within an organization’s functions.

TWO FORMS OF INTEGRATION GROWTH



TANGENTIAL INTEGRATION HIERARCHICAL INTEGRATION

FIGURE 3

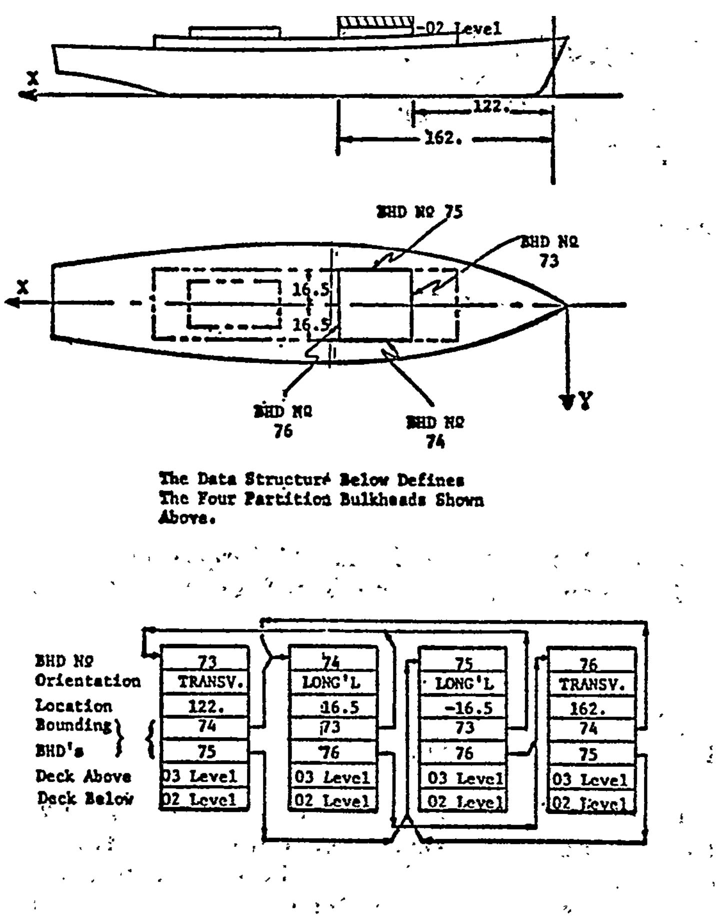
As an example of hierarchical integration, in the Navy's Computer-Aided Design and Construction (CASDAC) system (reference 9) we have seen manual dsiign tasks replaced or facilitated by stand-alone computer programs (e.g., the UPLOT programm for computer-assisted drafting). Stand-alone programs have often been consolidated into suites of complementary programs (e.g., combining UPLOT with an interactive graphics arrangement program, COGAP, to provide improved arrangements drawings). Program suites have been superseded by larger "subsystems" "which address entire design disciplines (e.g., the new Arrangements Subsystem provides a full complement of ship arrang ernents functions, including those of COGAP/UPLOT). These subsystems must be interfaced to comprise a total coordinated computer-aided contract design system "(CASDAC Level III), and this system will eventually be required to interface with shipyard design and with the vendor community.

Whether a particular step toward higher integration is predominantly tangential or predominantly hierarchical, the most common motivation is the situation where a new and common functional boundary exists, across which information passes and which is inefficient to support manually. Before integration, this data flow requires manual (or perhaps computer-assisted) copying, reformatting, calculations and/or re-digitizing (e.g., card punching) which incur inordinate expense and which could be alleviated by making the two functions or programs or systems "talk to each other." As an illustration, consider how interactive graphics parts nesting bypasses the plotting and cutting out of small-scale parts templates, the manual nesting of the templates, the recapturing of digital part position data via digitizer or manual card punching, and the verification of nested formats in batch mode plotting. Hence, another step up the integration ladder.

There are several other visible trends in shipbuilding computer systems which are accompanying the higher integration. There has been a startling popularity in the last two years of interactive graphics, whereas the traditional mode of operation has been batch mode with punched card input. Interactive graphics technology has come of age, and is finding effective roles in parts definition, nesting, and arrangements.

Another definite trend is the increasing cost of the more complex, more highly integrated systems. One shipyard indicated that the operation, maintenance, and modification of its N/C system required the continual effort of between three and six programmers. The cost estimated to convert to a second computer and to document another large, contemporary shipbuilding system is well into seven figures. Our computer software is becoming a very expensive commodity of the trade.

Finally, a trend of vital importance to this discussion is that system developers are recognizing the design data base as the central element of the design system. The British Ship Research Association (BSRA) describes their Base System as the "kernel" of their new Ship Structural Design System (SSDS). A particular characteristic of progressive design data bases is their use of topological data structure. This technique is currently being used in defining the spatial retionships among surfaces, lines of surface intersection, and volumes bounded by the Surfaces. With this method the absolute coordinates of intersection lines are not explicitly recorded; instead, the geometric shapes of the intersecting surfaces are recorded and are retrieyed and operated upon to compute the lines of intersection when these are required. Figure 4 illustrates such topological data in a Navy arrangements program (reference 10) and Figure 5 illustrates topologically recorded intersections between longitudinal surfaces (decks, bulkheads, tank tops, etc.) and the hull in Italcantieri's SCAFO system.



SAMPLE TOPOLOGICAL DATA STRUCTURE IN

THE INTEGRATED SHIP DESIGN SYSTEM

FIGURE 4

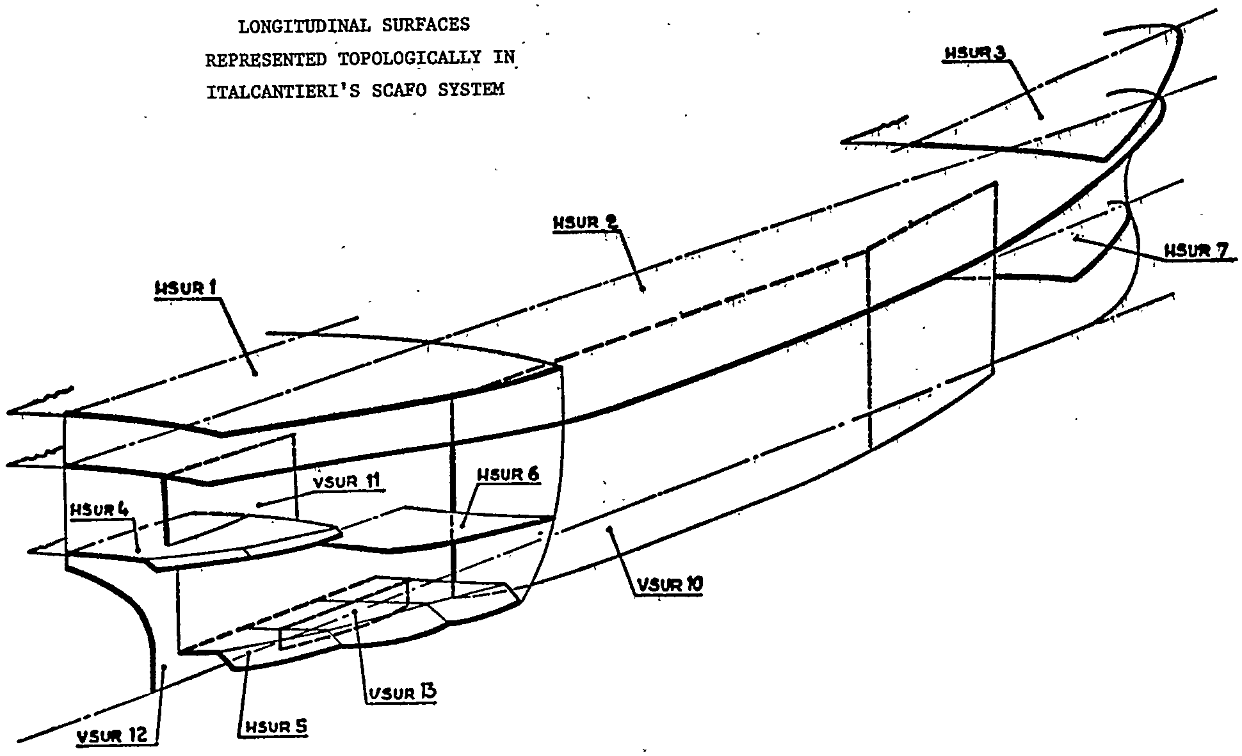


FIGURE 5

In his paper (reference 1) for the 1977 REAPS Symposium, Jan Mack identifies and discusses these three benefits of topological data structure:

- Less data input
- Ease of updating changes
- Flexibility in work sequence

It should be noted that a corollary to "ease of updating changes" is the fact that in a topological data structure data redundancy is minimized and therefore the data base is inherently more consistent. Italcantieri claims that SCAFO's topological data structure affords a

very desirable flexibility in work sequence, due to the fact that changes to the molded surface locations of both shell and internal surfaces do not require radical recomputation of many structural details.

It should be understood that the benefits of a topological data structure described above are germane while the data are in a state of change. Once a design has stabilized, it is often more efficient to freeze the design and record the data in absolute form for direct use thereafter. An, effective data management system should allow this transition from topological to absolute data representation during each design.

THE PAYOFF

Why Benefits Are Expected

Before contemplating the specific anticipated benefits of more highly integrated systems, it will be helpful to understand the mechanisms at work which yield these benefits. I will identify and briefly describe three such mechanisms.

MECHANISM #1: ONCE DESIGN INFORMATION IS "CAPTURED” AS DIGITAL DATA, IT CAN-DRIVE MANY APPLICATIONS.

As a familiar example, consider the spin-off benefits which became available at very little additional effort once N/C systems had recorded shell plates and hull longitudinal. Roll templates and 3-D templates for developed plates were easily produced. Inverse curve data for bending frames and longitudinals was made available, and tables of pin heights for shell assemblies were generated. These capabilities eliminate much manual transcribing of data, checking, and resolving of errors.

Similarly, it is a trivial matter to compute percentage of scrap and times required to punch and burn each plate, given information required for an N/C tape itself.

MECHANISM #2: SHIFTING THE "DIGITAL FRONTIER" FROM THE PARTS PROGRAMMING STEP TO A POINT EARLIER IN THE DESIGN PROCESS GREATLY REDUCES THE QUANTITY OF DATA TO BE LOADED.

We know that the quantity of design information grows exponentially during the design process, probably as the exponential "S" curve illustrated in Figure 6. Presently, detail structural design is performed manually, and at the conclusion of detail design the structural

MECHANISM #2: SHIFTING "DIGITAL FRONTIER" FROM PARTS PROGRAMMING TO EARLIER IN DESIGN PROCESS GREATLY REDUCES QUANTITY OF DATA TO BE MANUALLY LOADED.

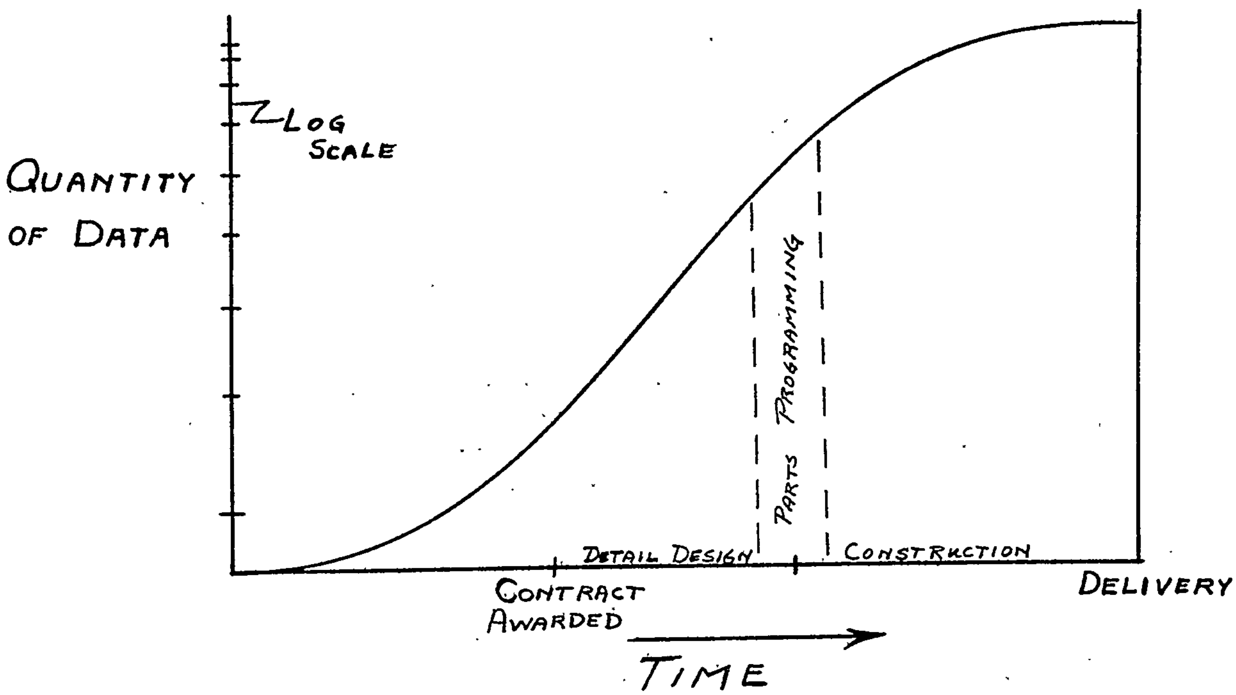


FIGURE 6

geometry is transformed into digital data during parts programming, a very time-consuming task. As the increasing usage of CAD in detail design shifts this "digital frontier" up earlier in the design process, less input will have to be manually loaded and the bulk of the input data required later in the process will be generated by the new design programs.

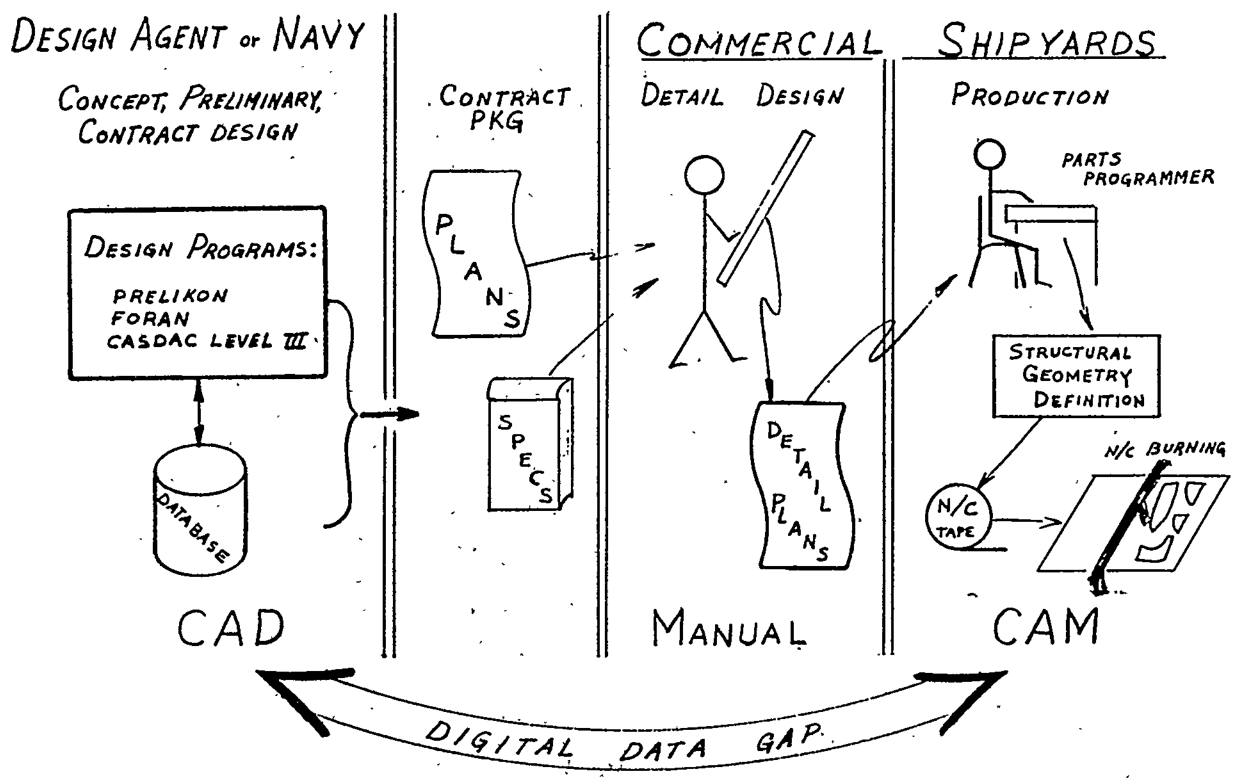
MECHANISM #3: INTEGRATED SYSTEMS CAPITALIZE ON CONTINUITY OF FLOW OF CONSISTENT DATA THROUGHOUT THE PROCESS.

We have already been introduced to this concept as the most frequent motivation for integration. Since the manual handling of digital data is generally espensive, error-prone, and unnecessary it is useful in system design to be conscious of continuity of data flow in the system, recognizing that flow continuity usually requires that the form of data be consistent as well as the information content.

Bearing in mind these three mechanisms and recognizing that various computer-aided design software exists now or is under rapid development in the early design stages (PRELIKON, Sener's FORAN, Navy's CASDAC Level 111), detail design stands out *as* representing the major gap in the flow of digital data (see Figure 7). As the CAD software in early design matures to produce a complete, reliable contract design data base, and as current development efforts move the digital frontier backward from parts programming across detail design to meet that data base, we may expect to see a marked improvement in the effectiveness of our system as that gap is bridged. Such integration of the design and manufacturing functions will realize much greater benefits than would the independent sub-optimizations of each.

Benefits in Structural Design

Once the structural geometry definition of the ship. is being stored and used in digital form, the structural engineer will have a versatile and convenient means for obtaining graphic representations of the current structural configuration. He may request plans for whole decks or bulkheads, he may ask for sketches of arbitrary sections through existing structure, or he may ask for particular local details. He may identify which views he would like shown and how he wants them formatted on a drawing. He may designate which structural surfaces or elements he wants shown, the level of detail he wishes depicted (scantling drawing, structural drawing, structural details), and he may selectively call for inclusion or suppression of notes, piece numbers, weld symbols, labels, dimensions, etc. In short, the engineer no longer must pick the information he needs off standard drawings whose format and content were



CAD MUST INTEGRATE ACROSS ENTIRE DESIGN/PRODUCTION PROCESS.

FIGURE 7

decided by others; he may now very quickly compose sketches and drawings to suit his individual and immediate needs.

The structural graphic representations just described would be available via several mediums. Interactive graphics terminals would serve as the primary man/machine interface. The engineer would compose displays exercising the capabilities and options described above. He would get electrostatic copies of the displays virtually instantaneously, and he would use these copies directly for reference in much of his own design work. High quality drawings, when required, would be produced from the graphics display via drafting machine.

In one of our more progressive shipyards which uses one of the popular N/C systems, engineers have begun to request drawings of molded contours from the N/C data base. These drawings they then arrange in appropriate locations under a fresh. sheet of mylar and the contours are manually traced as the outlines of their new bulkhead drawings. Certainly this procedure can be adjusted to more conveniently serve the engineer's need, but the significant point is that the data base and its graphic output capability have been recognized as a precise and reliable means of obtaining molded surface information. It certainly beats manual interpolation from a book of offsets, or scaling down a 1/10 body plan to an appropriate scale! The proposed capability for producing displays and drawings of the structural configuration is merely the extension of this basic capability to its full potential.

The last few paragraphs have described both passive and interactive graphics as useful output tools. Interactive graphics will also be used to provide the designer with a convenient and powerful tool for defining-structural geometry to the data base, eliminating most of the card input/batch mode data entry we know today. Programs on interactive cathode ray tube (CRT) scopes will display existing structure as described above, then will assist in structural design by quickly arranging grids of stiffeners at designated spacings, running seams and stiffeners parallel to existing structure, repeating groupings of minor structure, etc. Immediate visual confirmation will reduce input errors common in batch mode operation. Where appropriate, computer-produced sketches of existing structure can be manually marked up to show modification and/or new structure, and these modifications can be input via digitizer device working from the marked-up sketch.

Topological data methods would be used not only to represent molded surface intersections, but also to record stiffening located on a surface and to identify the extents of structural numbers. For instance, toe traces of bulkhead stiffeners might be defined to align

with a deck longitudinal above and a bottom longitudinal below. If the location or scantling of the deck longitudinal were to change, it would require no modification to the topology of the bulkhead stiffener. Since detailed piece lengths and end cut details would not be stored explicitly, they would require no updates. The structural design tasks would realize the benefits of topological data structure discussed earlier in this paper.

Structural piece lists could be, generated with practically no effort and in virtually zero calendar time. Manual "material take-offs" from drawings would disappear and the piece lists would be consistent with both drawings and data base. Furthermore, variations of piece lists could be tailored to particular uses at very little cost, to provide various formats, meaningful subsets of lists, or different ordering of list items.

Availability-of digital structural data would feed a variety of analysis programs from simple section, rnodulus calculations, to indeterminate frame analyses, to providing data for a closer interface with finite element methods. Structural weights and centers of gravity could be computed automatically, precisely, and-as often as necessary.

The existence of a structural data base would assist in foundation design by providing s-ketches of local primary structure. The digital description of equipment location, coupled with graphics templates of mounts, base plates, bolt hole configuration, etc., would enable superposition of mounting details on the local structure sketches. The convenience of this capability alone would considerably facilitate the manual foundation design task. A more ambitious interactive foundation design capability would, compute support forces due to various loads, would allow the designer to interactively describe the foundation structure, would compute forces and stresses in the foundation structure, and would allow the designer to indicate recommended modifications to the local principal structure, if ne,ceyisary.

Finally, benefits will be realized from linking the shipyards' detail design CAD systems with contract design data bases produced by design agents or by the Navy using CAD in the early design stages. This availbility of scantling plans in digital form will further reduce the initial data loading effort required in the yards, will make digital structural data available to all design disciplines very early in detail design, and will greatly reduce the number of consistency-type errors in the contract design package.

Benefits of Integrated Structural Design to Other Design Disciplines

The capability to obtain graphical displays, 'sketches and drawings of structural configurations would be available to designers in all disciplines. These designers would call for structural background graphics in whatever useful views they require, upon which they would variously carry out their tasks of equipment arrangement, piping and wireway routing, locating vent trunks and ducts, etc.

The integrated data base would contain equipment locations and details of piping connections on equipment, thereby providing precise end position and details for piping design.

A consistent record of structural penetrations would be maintained by the data base, correlating each penetration with the pipe, cable or vent duct involved, establishing the precise location and representing the details of the penetration.

The greatest benefit to be realized by integrating structural design with other disciplines will be regarding the control of physical interferences. Composite drawings and displays would acquire data from all disciplines to combine components from all relevant systems into one picture. As with the structural graphics capability, any views and various levels of detail may be prescribed. Several colors may be used to distinguish among systems. The composite capability would be cheap, easy, and would provide data highly consistent with the various system designs. Ancillary capability would include interactive resolution of interferences by allowing on-the-spot recommendations for modifications to remove conflicts, and analysis modules which would automatically detect interferences.

New Benefits to Production

When the design/engineering functions begin using CAD, new benefits will accrue in the production process itself and there will be a marked improvement in economy of transition from design to production. The parts programming effort will be greatly reduced since a comprehensive digital description of the structural geometry will already exist.

In most shipyards using N/C methods the production is responsible for interpreting structural drawings, for loading the structural geometry onto the data base, and for updating the N/C data base in accordance with successive waves of drawing revisions. Much effort is currently expended in identifying these design mods and in the requisite data update. The production department in the future will be relieved of this responsibility, since an up-to-date, approved data base will be availble to them as a natural product of the integrated design process.

Having captured basic structural design in digital forms, these data become a "valuable resource in production planning. The structural pieces can be easily organized to form the assembly tree structure, thereby establishing the assembly units and assembly sequences. Assembly units would be complete with all small parts accounted for, and assembly weights would be computed automatically. Most N/C systems now provide N/C statistics, (burn path length and time, punching time, percentage scrap, etc.) as spin-off information for use in production planning. Similarly, a structural design data base would classify weld joints as to standard types and would quantify amounts of each joint type required during each assembly step.

Structural design data will also be massaged and outputted variously as specialized parts lists, special-purpose fabrication sketches, and isometric assembly sketches. Whereas these fabrication tailored shop instructions are expensive to produce manually, the computer can generate them very cheaply once the basic data are available.

Programs can assist in assembly lifting calculations by computing weight, center of gravity and forces, by showing the engineer the lifting sequence in interactive graphic animation, and by preparing sketches of the lifts in various possitions.

Benefits Due to Coordination of Computer Methods Across the Industry

We have already discussed the escalating costs of developing and maintaining shipbuuilding computer software and have noted that this trend is driving us toward-cooperative effort in such software. More and more, users' clubs of various N/C systems are working together to implement standard "norms," specialized input procedures, etc. Whereas in the early years of N/C systems it was quite common for individual shipyards to customize versions of the software for their own use, we can see in the SPADES and AUTOKON Users' Groups a higher level of cooperative effort. In short, a higher level of standardization is being tolerated to attain lower costs, but this standardization gives occasion for other benefits also.

Perhaps because of the tight control on SPADES software andthe consequent standardized usage among the SPADES community, SPADES shipyards have been able to subcontract among each other portions of designs, thus easing the scheduling bind and leveling their manpower curves. While this type of flexibility has always existed in manual design, it must not be taken for granted with CAD processes because yards or design offices must use compatible systems in order for such subcontracting to be effective. Standardization of computer methods across the industry will allow management to retain the subcontracting option.

More than any other ship buyer, the Navy suffers from lead-yard/follow-yard shipbuilding problems. The independent use of incompatible design software by different systems compounds the problem; cases have occurred where both lead and follow yards utilized CAD systems, but where the lead yard was required to repeat the design manually because the data from its CAD systems were unintelligible to the follow yard’s system. Translated into a national emergency situation, this peacetime cost problem becomes a severe constraint on the nation’s ability to rapidly produce naval and merchant fleets. As with subcontracting, a CAD system more integrated on the industry level will reduce the peacetime acquisition costs and the wartime defense constriction.

Finally, Industry-CAD integration would produce classes of ships -- Navy and commercial -- which are more nearly identical than most classes to date. This conformity has a significant impact on reducing life cycle costs attendant to logistics, spare parts, training, repair, and conversion.

NECESSARY STEP TO CAD PAYOFF

Development of mature, effective shipbuilding CAD systems to produce the aforementioned benefits is no straightforward, task. Figure 8 records a number of the major problems we are encountering as we move toward more highly integrated systems. These problems are discussed in reference 11. It is not the purpose of this paper to address all these issues or their solutions. We will look closely at the last problem noted for these reasons: (1) it has not generally been given recognition appropriate to its significance; (2) it must be addressed now or it will be too late; and (3) there is something we can do about it,

The problem to be considered is that throughout the shipbuilding industry we are developing shipbuilding software to address particular immediate tasks. This distributed development effort is largely uncoordinated and we may be sure that those "successful" programs and systems which emerge will soon need to integrate with other programs/systems, and that because of our lack of foresight, such integration will be difficult at best.

The Navy’s CAD development over the last decade indicates that the most serious barrier stems from differences in the ways that individual programs/systems represent their data. Programs/systems considered for integration generally contain overlapping sets of data. Each program has been designed to handle data to suit its own needs and has built into it determinations respecting the logical definition of data entities, the structure of the data, the data formats, and the various software to perform data mangement functions. These types of determinations represent substantial software commitments and alteration of the software to revise

PROBLEMS TO BE ENCOUNTERED WITH MORE HIGHLY INTEGRATED SYSTEMS

- RAP IDLY DEVELOPING TECHNOLOGY
  - GRAPHICS
  - DATA BASE MANAGEMENT SYSTEMS
- REVOLUTIONARY VS. EVOLUTIONARY INTEGRATION STRATEGY
- IMPACT ON CURRENT PRACTICE
- HIGH COST OF COMPUTER SOFTWARE
- SELECTION FROM AVAILABLE COMPETITIVE SYSTEMS
- CONCURRENT UNCOORDINATED DEVELOPMENT OF SOFTWARE. WHICH WE WILL SOON TRY TO INTEGRATE

FIGURE 8

these items is generally an expensive proposition. As we have seen, the trend is that when independent programs become productive, users recognize the inefficiencies of their manual interfaces and propose they be integrated. It is at this point that the data differences among the programs prohibit integration. If we are to turn the corner on the high cost of progressive integration, we must better coordinate the data aspects of our respective software developments.

Attacking the Data Consistency Problem

Let's consider what we can and cannot do to alleviate the data consistency problem in progressive integration.

First, we must be willing to project our vision beyond the immediate development tasks -- those which have visible cost justification -- to future needs calling for more complete integration. In this projection we must concentrate on the probable future data interfaces among system modules, identifying groups of design data which will be needed by two or more modules.

It would be very good if we were to be able to establish and enforce data consistency at the highest level, by agreeing to standard data management software and standard physical file structure. Although these measures can and should be used where possible at lower levels of integration (e.g., where programs are merged into subsystems within a company), it would be optimistic to think they could be applied now to industry-level system integration. Difficulties stem from the diverse requirements of applications, from the limited generality of today's data management technology in efficiently serving diverse requirements, and from the difficulty of accurately predicting long-range data management needs or state-of-the-art capabilities.

Accepting the impracticality of invoking those high level standards, let us proceed with the next best thing: to establish consistent logical definition of design data to serve immediate and long-term applications. Figure 9 summarizes those characteristics of data comprising its logical definition, as opposed to the physical definition of data. The segregation of logical and physical data definition is widely recognized as a critical factor in effective future systems. Interpreted to our situation, this segregation tells us that we users must get our logical definitions straight and that future data management systems must be responsible to provide efficient physical data structure without our applications programs being concerned with record length, blocking factors, string versus tree structures, etc.

The time for industry action in coordinating logical data definitions is now! Figure 10 lists seven different development, projects in the REAPS/

LOGICAL DATA DEFINITION	PHYSICAL DATA DEFINITION
1 REFLECTS THE WAY THE APPLICATION PROGRAMMER OR USER THINKS OF THE DATA.	REFLECTS THE CONSIDERATIONS OF THE COMPUTER SYSTEMS PROGRAMMER.
REPRESENT REAL WORLD ITEMS. OR APPLICATION PROGRAM MODEL OF THE REAL WORLD IN TERMS (IF ENTITES, ATTRIBUTES, AND LOGICAL RELATIONSHIPS AMONG ENTITES.	CONSIDERS WHERE ON STORAGE DEVICES A SET OF INFORMATION IS LOCATED, CONTENDS WITH RECORD LENGTHS, BLOCKING FACTORS, TYPES OF STORAGE DEVICES, TYPES OF PHYSICAL RELATIONSHIPS (STRING, LIST, ARRAY ORGANIZATION).
GOAL: TO PROVIDE APPLICATION PROGRAMMERS A NATURAL VIEW OF THEIR DATA, MAKING PROGRAMS EASIER TO DEVELOP AND MAINTAIN.	GOAL: TO ATTAIN EFFICIENT OPERATION ON WHATEVER DEVICES ARE USED.

SEGREGATION OF LOGICAL AND PHYSICAL DATA DEFINITIONS INSULATES APPLICATION PROGRAMS FROM CHANGES IN-DATA STORAGE DEVICES AND FROM CHANGES IN PHYSICAL DATA MANAGEMENT METHODS.

FIGURE 9

THESE CURRENT DEVELOPMENTS HEAVILY INVOLVE SHIP STRUCTURAL DATA:

- REAPS PARTS DEFINITION PROJECT
- REAPS COST ESTIMATING PROJECT
- NAVY'S CASDAC LEVEL III HULL SUBSYSTEM
- NAVY'S CASDAC LEVEL IV HULL SYSTEM (HULDAC)
- CONSOLIDATION OF AUTOKON76 WITH THE U. S. STANDARD AUTOKON 71 AND WITH THE NEWPORT NEWS, VERSION OF AUTOKON
- CONSOLIDATED AUTOKON/SPADES FEASIBILITY STUDY
- REAPS PROPOSED STRUCTURAL DATA BASE DEFINITION PROJECT

THE FUTURE IS NOW!

FAILURE TO COORDINATE LOGICAL DATA DEFINITIONS OF THE ABOVE DEVELOPMENTS WILL GUARANTEE MAJOR OBSTACLES TO NECESSARY FUTURE DATA INTERFACES IN THE U. S. SHIPBUILDING INDUSTRY.

FIGURE 10

Navy community alone, in which digital structural design data play a major role. Failure to coordinate the logigal definition of structural data in these projects will guarantee the existence of major obstacles to necessary future interfaces in the U. S. shipbuilding industry.

Several pioneering efforts have been underway this last year to contend with logical structural data definition. In our work with the Hull Detail Design and Construction (HULDAC) System, covering the hull discipline for CASDAC Level IV/V, we have been investigating methods of recording logical data definition for ship structure. Figure 11 is an example of part of a typical logical definition. We are coordinating our work on the hull data base evolving from that of the Naval Ship Engineering Center's CASDAC Level III Hull Subsystem, and we have been following closely the ongoing REAPS projects and have been including in the HULDAC study structural data requirements indicated by those projects.

In particular, the HULDAC work has been closely keyed to the Structural Data Base Definition effort initiated by Dick Moore of Newport News Shipbuilding Company and Doug Martin of IITRI and proposed to be adopted as a REAPS research and development project. At the February 1978 REAPS Technical Representatives Meeting, IITR1 presented a Project Proposal Abstract and a Working Paper describing this proposed project and requesting technical inputs from the REAPS member yards. Initial response to this effort was not enthusiastic, apparently because the relevance of this project to the future anticipated benefits of computer usage in shipbuilding was not clearly set forth. It is the purpose of this paper to illuminate and publicize the rationale for this project.

Recommended Action to Coordinate Ship Data Definition

Figure 12 enumerates several actions which should be taken to better coordinate the logical definition of ship data. These actions should concentrate first on structural data due to the intense development activity in this discipline, but should eventually be extended to include piping and other design disciplines.

A key component of this effort should be the execution of Structural Data Definition as a REAPS research and development project, with active support in defining data needs from knowledgeable structural engineers within each yard. Close liaison must be maintained between this project and the structural data being defined by the Navy to serve HULDAC and CASDAC Level III.

Once an acceptable Structural Data Definition has been created, a challenging organizational/control problem will be to establish a continuing mechanism whereby developers and users of shipbuilding systems will be influenced to observe the standards.

LOGICAL DATA STRUCTURE

PLATE
    PARENT-SURFACE
    MATERIAL-CODE
    THICKNESS
    EDGES (RG)
        CONTOUR-NAME
        EXCESS-STOCK
        BUTT-JOINT-DETAILS (RG)
            ADJOINING-PLATE
            STD-JOINT-TYPE
        MOLDED-EDGE-CONTOUR
    AUGMENTED-EDGE-CONTOUR

LOGICAL DATA I) DEFINITIONS

PARENT-SURFACE: IDENTIFIES THE DECK, BULKHEAD, SHELL SURFACE, ETC., WHIHIcH CONTAINS THE PLATE

EDGES (RG): REPEATING GROUP OF PLATE EDGES, EACH EDGE BEING DEFINED BY A BUTT, SEAM, OR INTERSECTION CONTOUR WITH ANOTHER STRUCTURAL SURFACE (E.G., MAIN DECK AT EDGE).

FIGURE 11

RECOMMENDED COORDINATION IN SHIP DATA DEFINITION

- CARRY OUT STRUCTURAL DATA-DEFINITION PROJECT AS FORMAL REAPS PROJECT.
  - YARD PARTICIPATION TO REVIEW DEFINITIONS AND USAGE.
  - COVER DATA IN USE AND DATA FOR SOFTWARE BEING DEVELOPED.
  - CLOSE COORDINATION WITH NAVY DATA DEFINITION.
- ESTABLISH MECHANISM FOR CONTINUING DATA COORDINATION.
  - CASD DEVELOPERS MUST ADHERE TO STANDARD DATA DEFINITIONS.
  - CASD DEVELOPERS MUST SUBMIT NEW DATA FOR INCLUSION.
- EXPAND DATA DEFINITION TO INCLUDE PIPING, HVAC, ETC.

FIGURE 12

SUMMARY

It has been shown that two of the most dominant trends in the continuing evolution of shipbuilding software systems are the increasing cost of developing and maintaining this software and the recursive cycles of higher integration being sought, especially now in the *detail* design/engineering functions. We must recognize these trends and lay strategy to accommodate them through more cooperative effort and by extending our vision in system planning beyond the immediate development tasks to encompass the imminent higher levels of integration beyond.

The effects of-the trend toward higher integration are expected to produce large benefits to the design/engineering functions of all disciplines, to produce additional benefits to the production function, and to upgrade the effectiveness of the U. S. shipbuilding industry as a whole.

One very important necessary step toward long-term 'integration is to gain control of the diverse logical data definitions,bei:ng built into concurrently developed programs and systems. A number of current developments involve overlapping structural design data and the involved parties -- REAPS and the Navy in particular '- should actively promote coordination of this common data.

The Structural Data Definition project should be recognized as a vital undertaking, to be pursued with vigor and with high level support from shipyard management.

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MAPS-GP (GRAPHIC PIPING) PRESENT AND FUTURE CAPABILITY

Kenzou Kobayashi
Mitsui Engineering and Shipbuilding Company, Ltd.
Tokyo, Japan

Mr. Kobayashi is a member of the engineering department in the system headquarters and is the group leader of the team developing MAPS-GP. His past experience includes work with a graphic N/C system for steel plate flame cutting and a graphic piping system for a chemical plant.

Mr. Kobayashi is a graduate of Tohoku University, department of science.

MAPS

Ž Qriginaly

Ž Mksui Automated Pipe Shop system

(Mitsui Shipbuilding & Engineering Co., LTD.)

present

Ž Mitsui Advanced production System

(Mitsui Engineering & Shipbuilding Co., LTD)

MAPS-GP	;	Graphic Piping system
MAPS-NC	;	Graphic Steel plate Cutting system
MAPS-DATA	;	MD 7000 work station terminal
MAPS-GRAPH	;	YM9000 satellite graphic terminal
MAPS-M	;	Modularized plant production

Why MAPS-GP?

- High . . . Low Economic Development
  - Alter company's need
    - Reduce Input Cost
    - Shorten the EXEC. Time
    - Change Organization
  - Enhance production design
  - Distributed System Request

Long Range Plan of MAPS-GP

Step	Range	Object	Technology	Need
	1970–75	Ž Numerical Information System Ž Automated Pipe Shop	•Large scale Computer Ž Part coding & Batch job	ŽMass Production system Ž Improved Shipbuilding Ž Large scale investment of equipment
	1976–78	Ž Separation the routine and judgement work •Elimination Part coding •Reduce the TAT'	Ž Interactive Computer Graphics Ž Distributed Systems	Ž Reduce ship acquisition time Ž Design power up Ž Cut the equipment
	1979-80	Multi purpose system Cut off the drawing work High speed data input	Ž High accurate digitizer Load sharing System Large scale file	Concentrate design office Wide range application Separate production design
IV	1981–	•Automated piping design Ž Perfect unmanned pipe shop	Ž Computer Network Ž Advanced CAD/CAM Ž Full Automated pipe shop)	Engineering power up . Concentrate production management

. The Object of II step MAPS=GP

- Low Cost
  - Simultaneous operation with GNC system ..... effective use
  - Ž Cost down . . . . . 30% of design cost
  - Ž Shorten the **design time**
  - Ž **Improve: the design accuracy**
- **Step by Step Approach**
  - **Eliminate part coding**
  - **Move the most load from center to work station**
  - **Shorten** T. **A.** T.
- Ž **Output Production Management Data**
  - **Reduce the Pipe shop idle time**

System's Characteristics

Interactive Graphics

ž Tutorial Operation

ž Function Key

ž Easy Programming

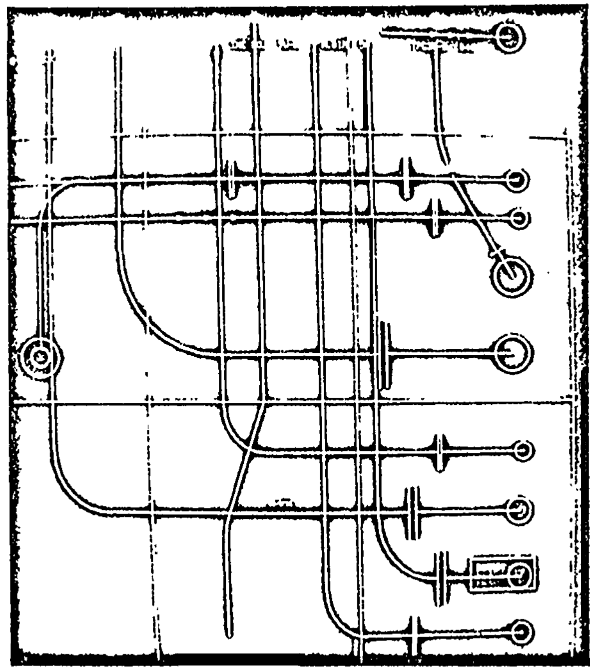
- instant Correcting Errors

Operation Functions

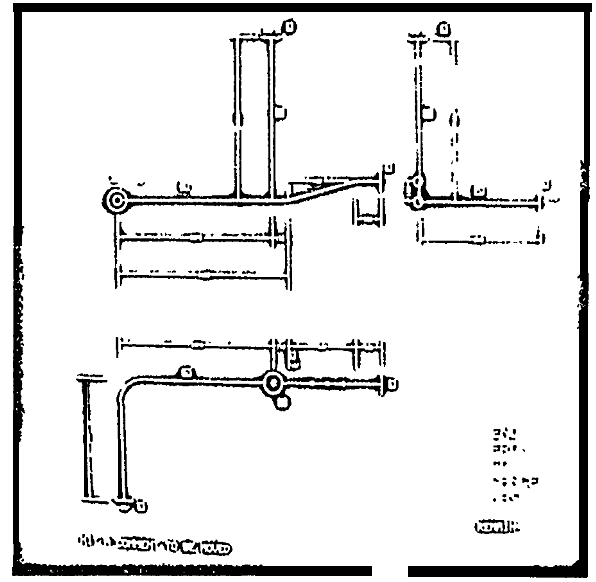
- Ž Pipe Line Generation

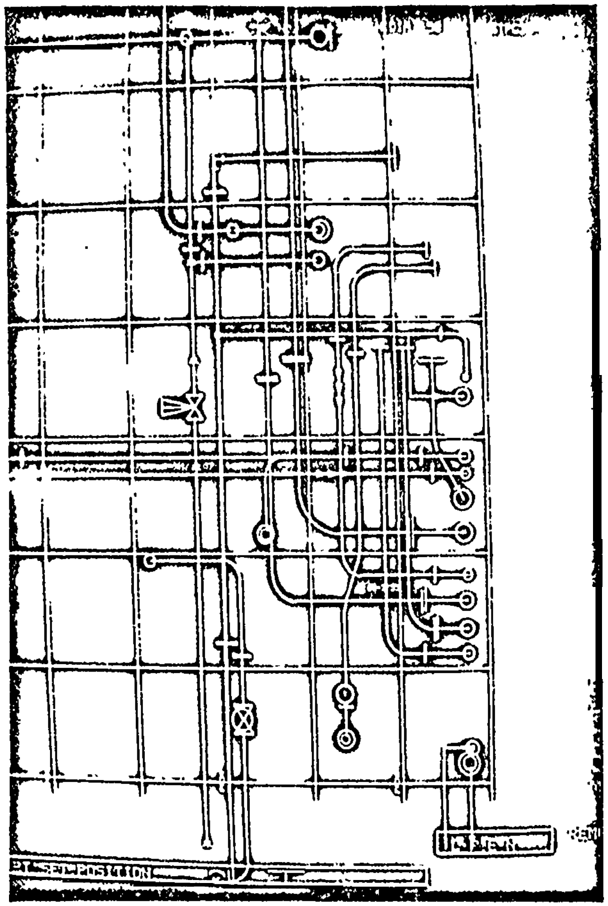
  (Piping Root, Node Point, Branch)
- Setting parts
  - Valve, Reducer, Flange, Elbow , ...
- Ž Pipe piece Data Generation
  - Ž NC Cutting & Fitting control Data
  - Ž NC Bender Data
  - Ž pipe piece Drawing . . . . Dimension, comment
- Ž Scale
- ž View change
- Ž Display Hull Line
- Ž Change

scale up

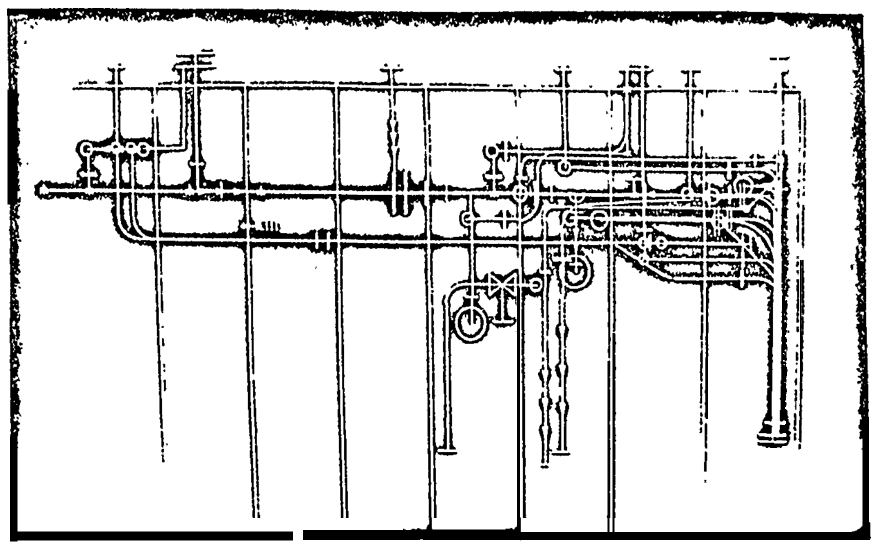


pipe piece





plan



view change

YM-9000 GRAPHIC DISPLAY

Remote (Full, Half duplex), or Local

- **Refresh type CRT display**
- **17 or 21 inch Screen**
- **2048 X 2048 dot matrix**
- **16 intensities**
- **Blinking, Scroll, Rotate**
- **Light pen, Tablet**
- **Random scan**
- **Analogue stroke**
- **using 2 μ processors**

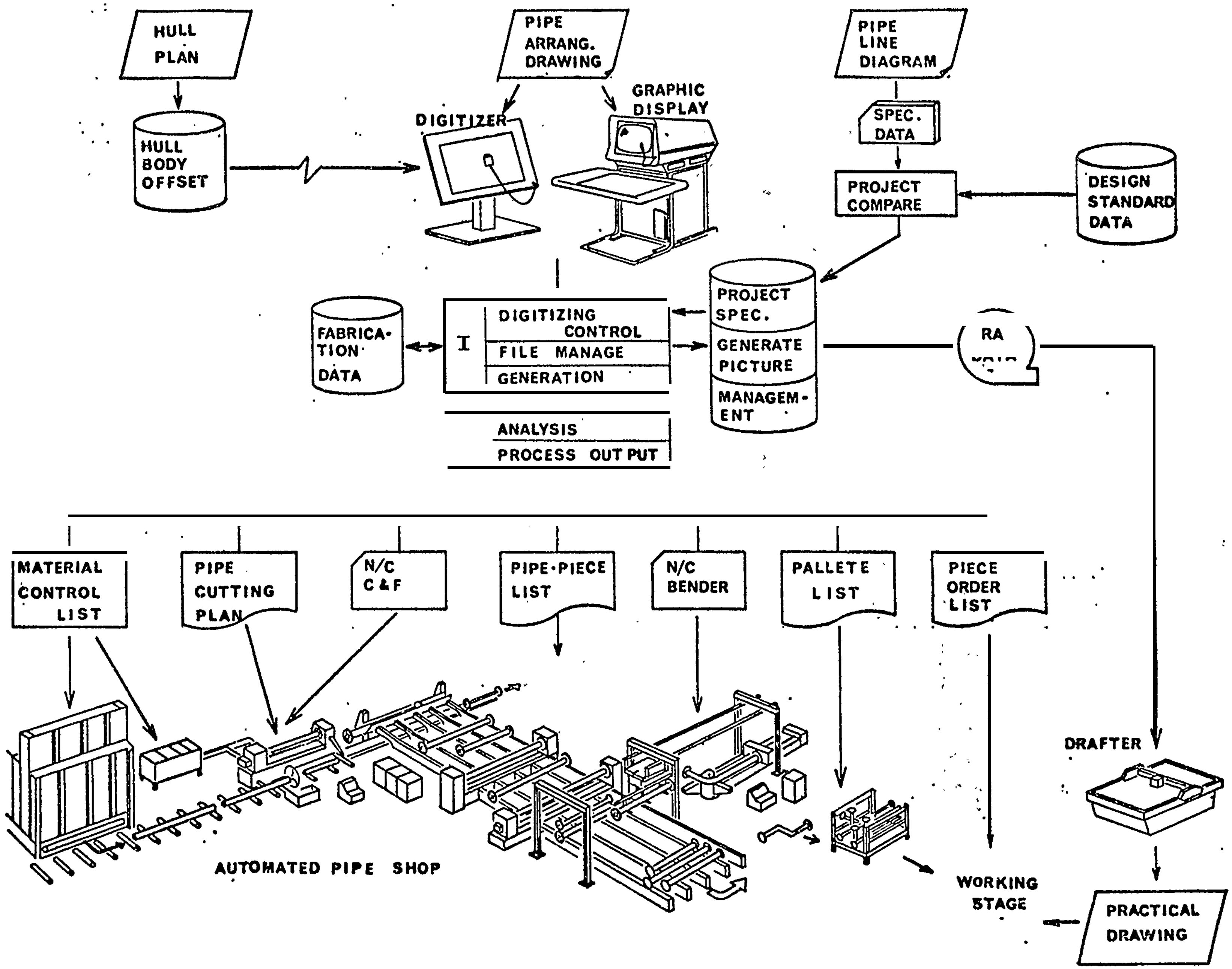
MAPS - GP Software

- Application Sofware
  - Geometric functions
  - File data management
  - Interactive graphic package (I. G. P.)
  - standard data file maintenance
  - Generate production management data
- Support Software
  - G O S (Graphic Oprating System)
  - Multi programming (4 job)
  - Virtual memory management
  - Fortran executable

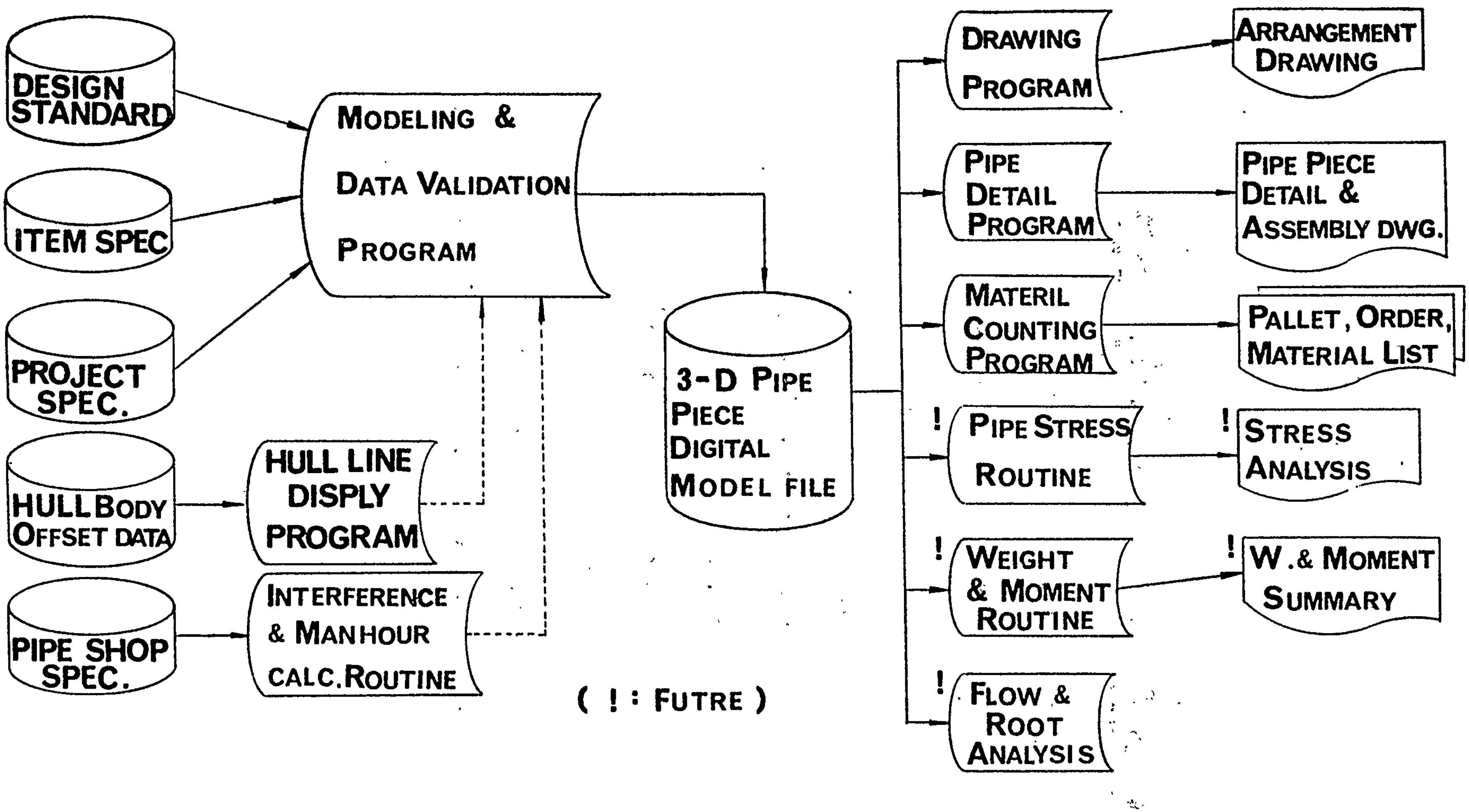
III Step MAPS-GP

- Improve the IIstep MAPS-GP
- Complete it as a tool of production design
- promote the high contact with pipe shop”
- Link with host machine (2400 ~ 48000 bpS)
  - Load Sharing System
  - Work Station Type
- Yard plan Drawing

System Diagram



OVERVIEW of FILES & SOFTWARE



MAPS-GP & OBJECTIVES:

- Total production cost down
  - Low cost automation
  - Enhanced Management control
- Maximize Man power & System resource
- Full Modularized System
  - Flexible system
  - Coordinate CAD/CAM System
  - Interface Engineering/Manufacturing
  - General purpose System
- Prmote GP system use by wide segment of industry

NEW SRS N/C SOFTWARE SYSTEMS DEVELOPMENTS

Paul F. Sorensen
Shipping Research Service
Oslo, Norway

As marketing manager for SRS, Mr. Sorensen is responsible for marketing of SRS services in general, with particular emphasis on computer information systerns. He is also involved in systems development.

Mr. Sorensen has an M.S. degree in naval architecture and marine engineering from the Technical University of Norway.

INTRODUCTION

SIAG is the Norwegian abreviation for the Central Institute for Industrial Research (CIIR = SI) and the Aker Group (AG), a cooperation which has lasted for almost 20 years.

SRS is also a member of SIAG, acting as the exclusive marketing organization at the same time as participating in the development projects.

The SIAG cooperation is working with a number of development projects, of which the two major ones are AUTOKON and AUTOFIT. Both are sizeable projects with the same ultimate goal, to develop CAD systems for the 1980-ies. The projects have many things in common, even if they cover two different engineering fields, steel and piping. Therefore, this presentation consist of four parts:

1. Basic assumptions for the SIAG/CAD developments.
2. Description of Interactive AUTOKON
3. Description of AUTOFIT
4. Hardware considerations

of which the first and the last are common.

PRESENT SIAG-DEVELOPMENT

PART 1:

<u>Basic assumptions</u>

Presented by
P.F. Sorensen, SRS

1. THE SHIPYARD'S MARKET PLACE HAS CHANGED

It is only natural that the needs of the Aker Group have been and are of the greatest importance when it comes to the question of setting the systems requirements. The Aker Group's market place has changed dramatically over the last 5 years. From being Norways biggest shipbuilder, accounting for about half of the total tonnage delivered from Norwegian yards, shipbuilding is now reduced to less than 20% of the groups activity and will probably have less and less importance. 80% of the activities are now concerned with engineering, production and outfitting of structures for the North Sea oil exploration. These changes are not significant for the Aker Group otherwise than that Aker has managed to switch in time. The whole shipbuilding world is facing the same problems.

1.1 Diversification of products

In addition to ships a number of other products have grown in importance

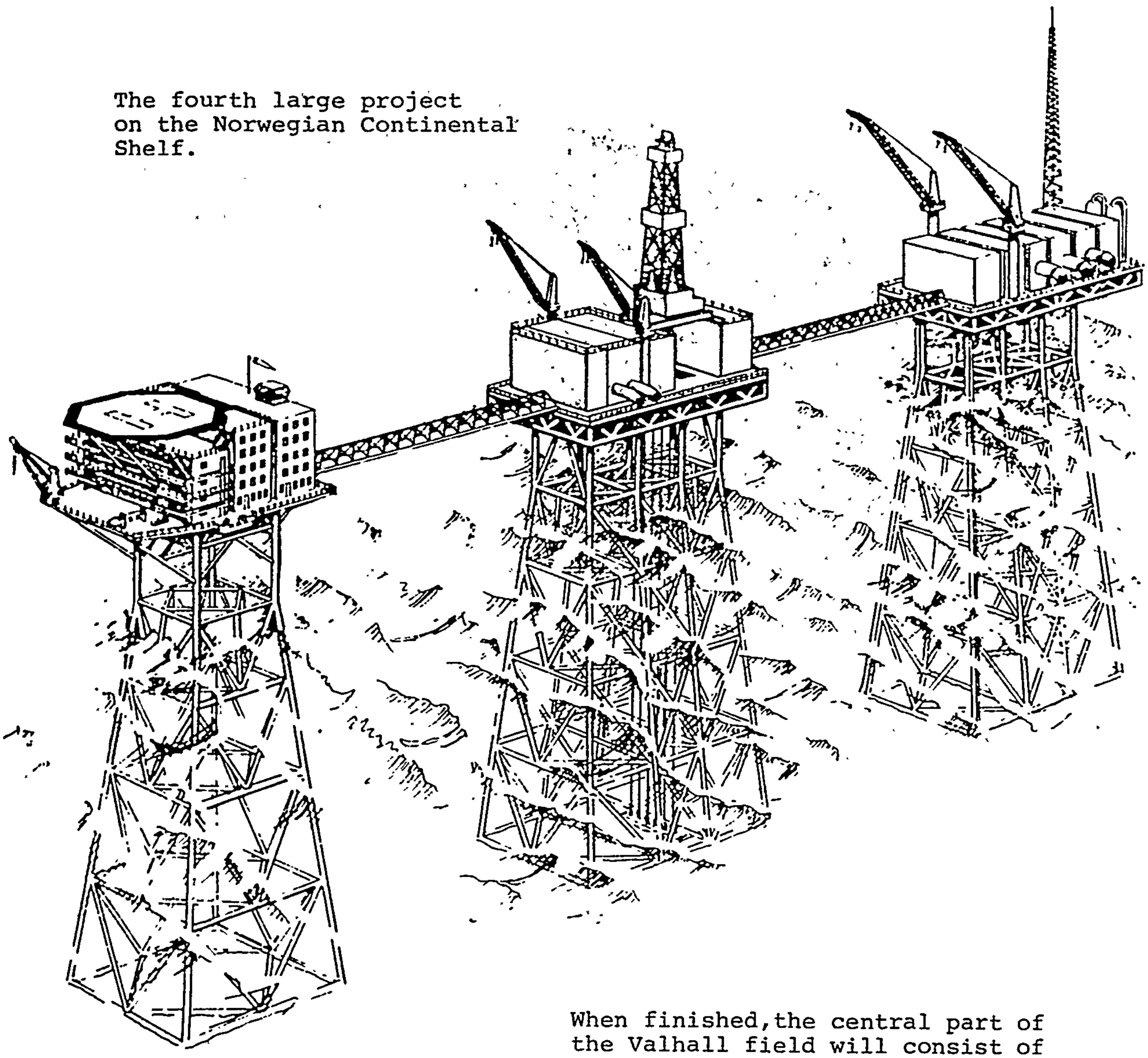
- Specialized offshore oilfield exploration and service vessels, frequently of the semi submersible platform type. Fig. 1.
- Offshore oil production facilities, "off shore cities" Fig. 2. Steel structures of the typical curved or flate panel type are replaced by pipe-truss structures, f.inst. for jackets.
- Concrete is substituting steel structures such as in the CONDEEP design. Fig. 3.
- These are just examples. Who knows what kind of products the present shipbuilder will have to cope with in the 1980-ies ?

1.2 The increased importance of outfitting

Some of the offshore products are a combination of a vessel and a process plant, a fixed or floating factory. Typical examples are the CONDEEP oil production platform and the Kværner's large project with gas liquidation plant and storage facilities. Fig. 4.

Valhall/Hod

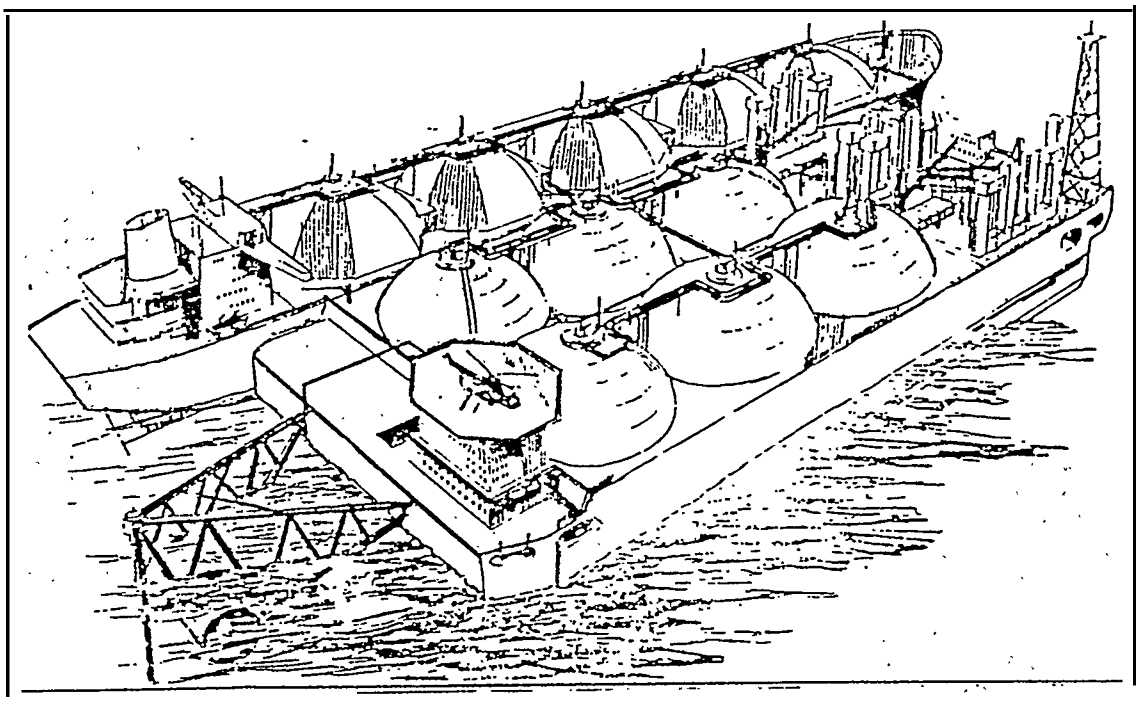
The fourth large project on the Norwegian Continental Shelf.



When finished, the central part of the Valhall field will consist of 3 steel platforms:

- accommodation platform
- drilling platform and
- production platform

Fig. 2



Floating gas liquidation plant and storage tanks. Behind the plant a gas carrier is loading

Fig. 4

Outfitting problems are increased by a factor 5 - 10 compared with convectional shipbuilding. Pi-ping systems, in particular, are of considerable size and complexity. The demand for efficient computer tools to handle piping engineering is therefore imminent.

1.3 The products are very complex prototypes

Little is left of the nice period of repetitive production of long series of ships. Not only are the product more complex in design, they are prototypes to a very large degree. There is less previous experience to build on. The frequency of design changes is very high. Both design and production engineering represent a tremendous task of coordination. Most problems occured are due to lack of proper product documentation which is either incorrect, inconsistent or missing.

1.4 Explosion in demand for documentation

Break downs in operation of the offshore structures may have enormous economical and environmental consequences. Extensive non destructive testing is required and puts heavy demands on administration of the quality control procedures and in particular on the documentation of results. Missing material certificates or inadequate reference of X-rays films to actual pieces of pipes or steel plates may cause costly replacements during production. This information is closely tied up with product itself.

Further the clients demand all kind--of reports as regarding the status of engineering and production. This was something quite different from the experience with shipowners, who normally did not care about the, builders procedures and methods, as long as the ship was delivered in time and according to specifications.

1.5 Lead time is short

Considering the fact that the products are complex prototypes, the lead time is much shorter than was the case with most ships.

Very heavy demands are put on “engineering” projects, detailed design documentation for prefabrication, shop assembly and field assembly. And not to forget materials supply!

Short lead time must be expected to be the rule rather than the exception in the future.

1.6 Product in focus

The shipbuilder is used to a kind of function oriented management, like a “production line” where similar engineering tasks on all products are “passing" the various engineering departments.

A much more product or project oriented management is demanded. In other words, the products is in the focus and all functions, either technical or administrative have to organize themselves, around the product.

The produtcts itself is the-source of all essential and necessary information for all functions supporting engineering and production.

1.7 More subcontracting

Due to the size and complexity of the projects we have seen examples where both engineering profabrication and assembly work have been farmed out to a number of companies spread all over the continent. It is evident that this puts some heavy demands for coordination on the main contractor.

What would be the main source of information to be able to control it ? First of all, proper products documentation.

These facts of life have some important bearing on what kind of computer aids we should look for, and they put some pretty heavy demands on systems development.

2. DEMANDS ON SYSTEMS DESIGN AND IMPLEMENTATION

If we look back on the AUTOKON development, the very fact that triggered it off, was the desire to feed a piece of work shop equipment with N/C burning tapes as efficiently as possible, The systems designed for the 1980-ies must incorporate quite substantially more and be radically more efficient than systems available in 1978.

2.1 High degree of products independence

This demand on systems design should be obvious from the previous section. Interactive AUTOKON will not be associated with stiffened "steel" panels only, but be equally applicable to any type of geometry and materials. AUTOFIT will be independent of purpose of piping systems: ship system, process plant systems for petro-chemical or chemical purposes. In AUTOFIT the goal is *even* higher, since the concept is basically general for analogueous out-fitting problems: piping, ducting, electrical.

2.2 Source for generation of product documentation

By tradition any product is implicitly described by its drawings. The drawings, tables and other documents represent the "database".

The same product (f.inst. a ship) may be documented in-just as many different ways as the number of yards building it, according to local needs and practices. And the same ship can be split into quite different prefabrication arid assembly units depending on local practice and facilities.

The nucleous of the system is therefore the computer based product model which represent the product "reality". The product documentation is basically reflections of this model in terms of composed layouts, presentation of different views, merging of drawings and tables etc., in other words, manipulated information with its origin in the product model.

2.3 Serve as document files (archives)

The computer based document file shall be the “original”. When the product model is modified the database “original” will be automatically updated, or at least the system shall advise on the consequences of the modifications. On the other hand, drawings may contain a variety of information which do not directly affect the product model itself. The advantage of having the “original” in the system rather than as a transparent paper in a cabinet drawer, is obvious. Technologically one is very close to solving the problem of using ordinary TV–screens to vizualize data bank contents, which may have a dramatic effect on distribution of documentation.

2.4 Serve as source of information in general

To be mentioned

- Analysis and calculations
- Other design and production engineering functions
- Materials supply
- Methods and planning
- Quality control
- Cost control
- Shop automation

In fact, the product model and document file comprise the very source of almost all information needed by any other function in engineering and manufacturing of the product.

In comparison with most technical systems of to-day, the potential “harvesting" effects are tremendous. The information system aspects are just as important as the “computer aided design” itself.

2.5 Excellent user communications are required

The above mentioned items are concerned with the properties of the information system as such. However, with to-days batch technology we would be very badly off when communicating with it. Therefore,

on-line interaction is a necessity to provide proper communication between the user and the system. It concerns both interactive graphics and on-line selective information retrieval on alpha numeric terminals.

Frequenlty, we see interactive graphics evaluated more as a goal in itself, rather than as a means of communication with an information system.

2.6 High degree of hardware independence

In our development we are aiming-at separating what to do from how to do it. The first aspect of the information system is rather statical over time, while the other is dependent on the current computer technology available. A major objective is therefore to create an information system which comply with the needs of the user without forcing him into complete-hardware dependency.

Software portability should be considered important by any user, because he will have to face the rapidly changing developments in computer technology. For us and from the point of view of marketing portability is crucial. We are convinced that the wide distribution of AUTOKON is partly to be credited to the fact that the system was reasonably portable. portability is not granted free of charge, it must be deliberately built into the system during development.

2.7 Standardization of software components

In order to obtain the desired implementation independency the systems are made selfcontained with regard to such facilities as database software, picture file system, command processor, segmentation system, general picture graphics, system, etc. Most of these software components are of general-purpose nature. Apart from serving above needs, they also facilitates standardization, which again means lower system development costs and system maintenance costs.

3. THE INTEGRATED PRODUCT MODEL

One of the ways to meet the various demands imposed'on the system is the introduction of the product model. Since so much em-phssis is given to the product model, this section will be devoted to an elaboration of this concept.

3.1 The problem to be described

What is to be described in the model ? The products which are considered here can be viewed in many ways. If interested only in the funciional purpose of the product as a whole, certain performance parameters may be sufficient.

If interested in structural detail, it may be necessary to have an exact description of shape and position of the detail. Due to the enormous amount of detailed structure which may be present in the considered products, the representation in the database is essential for a successful system.

Also the functional relationships in the detailed structure and the way such details are put together to form larger logical units is essential and must be reflected by the logical description in a simple and efficient manner.

To the model which thus emerges must be added various user functions like the output of reports/drawigs, generation of meshes for finite element analysis, etc. Also to be considered is the efficient handling of numerous updates and changes which is so typical to the process.

3.2 Some functional requirements

0 It must be possible to communicate with the model inter-actively by means of information in drawings, text and tables.

0 The data must be available for new and possibly unforeseen applications. The data must be stored and structured in a tidy and "modular" manner which allows restructuring.

- o Description of the model must be possible even though exact or final parameters are not available. The same model must still be valid when final parameters shape has been determined.

- 0 The consequences of updatings must either be considered automatically or the user must be told where and what to update.

- o Redundant data should be avoided as much as passible. A consequence of this (which has more meaning) is that if we feature is to he changed this should mean only one logical update in the database even if consequences are numerous.

3.3 The integrated product model

The purpose of a CAD/CAM system is to solve one or more design or manufacturing problems. Consequently the total data base model must primarily reflect the requirements of all the relevant applications. However, existing applications change and new ones are added. This implies a need for a central description reflecting the product in a general way rather than any applications. This central product model is the common denominator to all applications? Ideally it is not effected by changes or additions in these.

Applications do exist, however, and must be appropriately integrated in the system. The different applications in a total system may communicate with the product model in a number of ways (fig. 5).

1. The application works on a common data description (central product model). This model contains all the relationships and other information needed.

2. The application derives its data from the model. The derivation may be performed through procedures (programs) which produces new data. If the procedure is considered a part of the model, then the model is said to be procedure oriented.

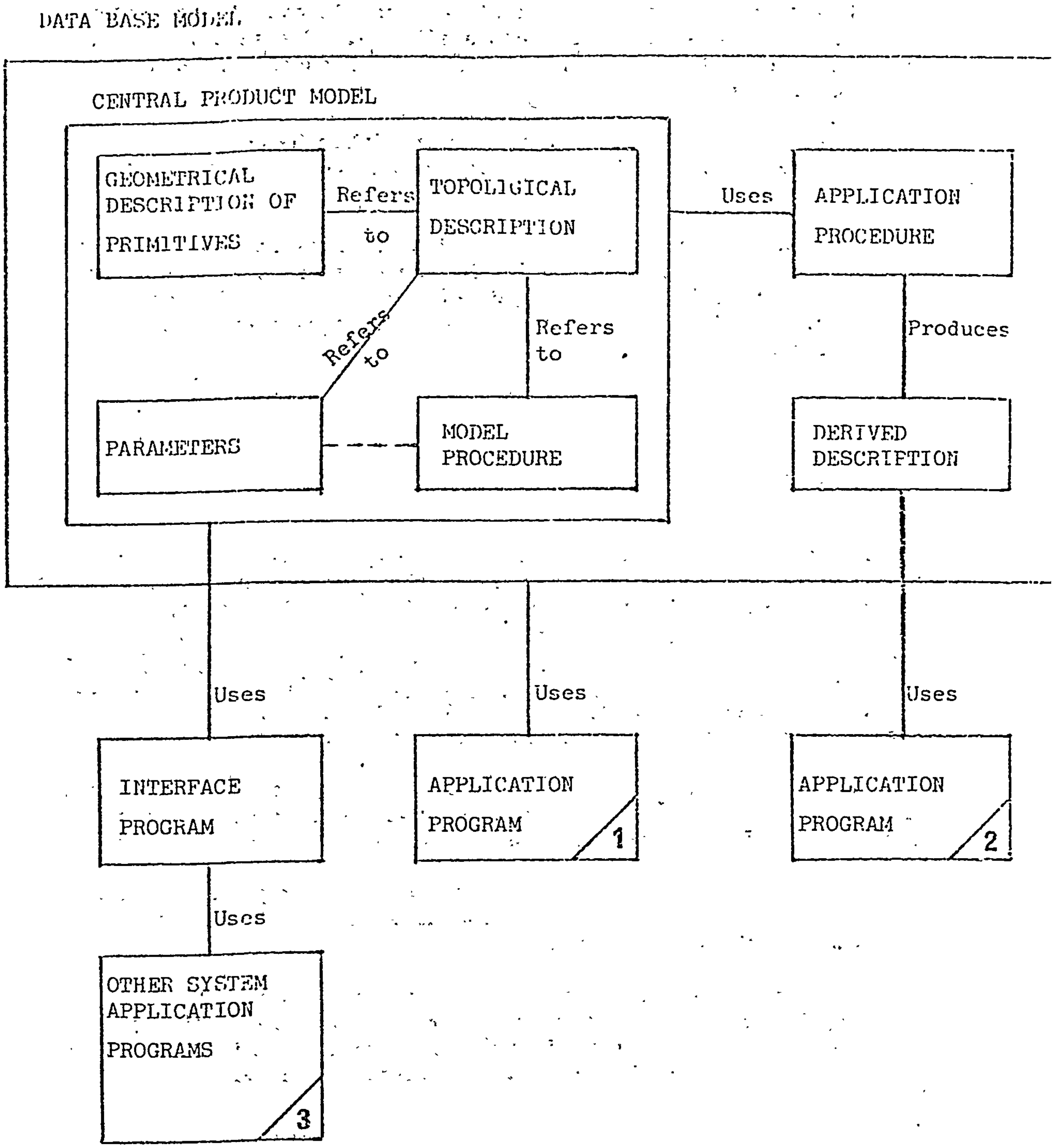


Fig. 5 How various applications may communicate with the product model.

3. Interface programs transform all relevant information to a suitable form which is used by the application. This solution results in several representations of the same data and hence consistency problems. It may, however, result in simpler data structures.

4. Data are derived manually from drawings, tables etc.

The product oriented model is the most static element in the overall database model.

3.4 The product model is change oriented

A common way of describing geometry in interactive graphics is by a number of closed or open planar polygons where each side of the polygon is described by referring to the endpoints. If any such point is displaced then all polygons involving that point will be changed as well. We wish to generalize this effect by using logical references for curves and surfaces as well as for points. The effects we wish to obtain is perhaps best illustrated by the following.

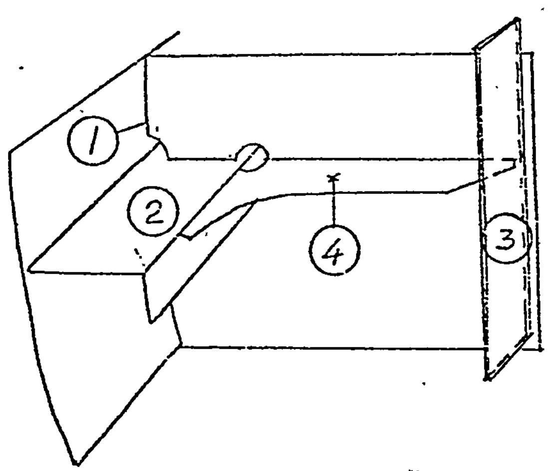


Fig. 6

In fig. 6 we have for example started off with a description of the shape of a ship hull. This hull may be defined in a variety of ways, but for the same of argument the representation may be a

set of transverse frames (1). The important point is that the longitudinal frame (2) and the flange of the web frame (3) is defined relative to the hull description. This means that primarily the data base contains a description of how (2) and (3) is derived from the hull description (1) for example by a reference to a parallel routine and the relevant parameters (parallel distance). Furthermore the bracket (4) is again defined relative to (2) and (3). Note that even if the geometry has not yet been described, the other features may.

The purpose of the product model is to describe the product by identifying its functional entities and their relationships or "connection structures". These connection structures we refer to as the <u>topology</u> of the product. The topological description is separated from, but may refer to, the geometrical descriptions. In cases of geometrical changes the topological description refers to sufficient information to generate the new geometrical solution.

This approach has the following advantages:

Only's minimum of geomentrical data is needed to describe the structure (minimum of data redundancy). Thus it means less work in the initial definition of the product.

The descriptions of topology and geometry are separate and independent of each other which means that for a ship the internal structure may be defined prior to having defined the hull shape. More generally this allows flexibility as concerns the work sequence in a typical engineering design process (fig. 7).

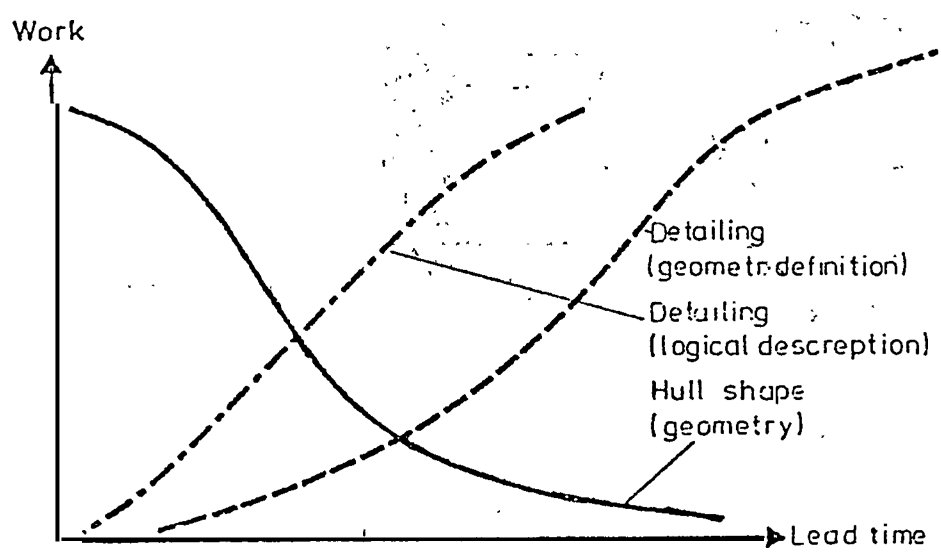


Fig. 7: Reduction in lead time.

All the geometric consequences of a change in scantling (the most typical change) will inherently be taken care of without additional changes to the data base. The ability to handle changes and updates is certainly a major problem area. The topological description should reduce this problem to a minimum giving a change oriented system.

Additional or alternative geometric representations are easily introduced. This is due to the fact that the major part of the product description is geometry independent and therefore does not change.

3.5 General layout of the database

At the top-level of database design, the system may be considered as consisting of two parts (see fig. 8).

1. Integrated product model:

   This part constitutes the internal model of the object (product, drilling rig, ship, production platform, jacket etc. or only part of these). Note how the "topological description" (TOPOLOGICAL UNITS) are separated from the parametric descriptions (SURFACE-, POINT-, CONTOUR UNITS) the former only referring to the latter.

2. Commiinications:'

   This part takes care of the communication with the central database and also contains the archives of the reports/ documents which have been made.

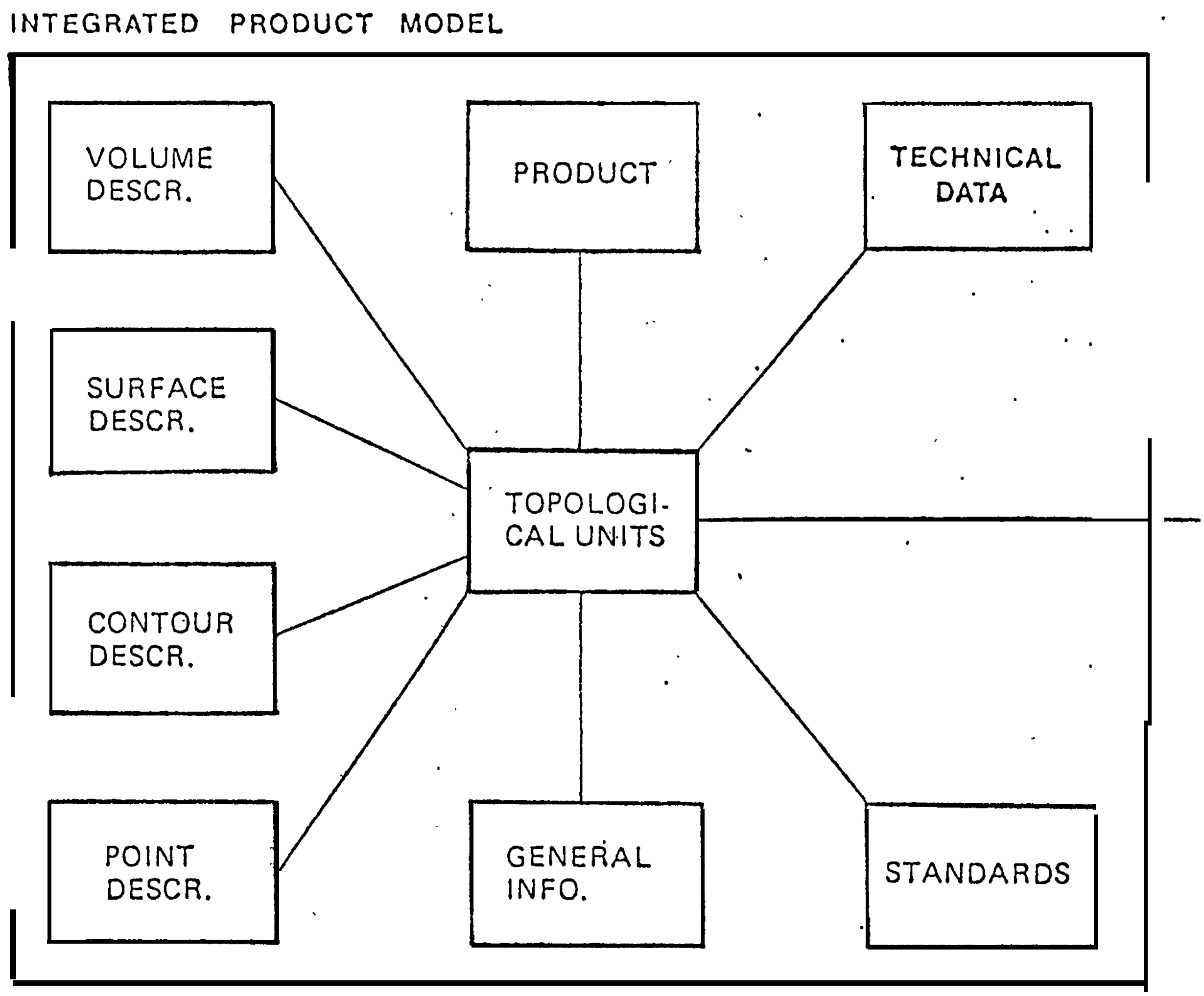


Fig. 8 THE COMMUNICATION DATA STRUCTURE

PRESENT SIAG-DEVELOPMENTS

PART 2

Interactive AUTOKON

presented by
P.F. Sørensen, SRS

FRESENT AUTOKON APPLICATION IN BATCH TECHNOLOGY

It is considered appropriate to give a summary on the present AUTOKON before elaborating on the new developments.

The existing AUUTOKON applications in batch–technology is based on the use of a set cf FORTRAN programs labelled AUTOKON-76 with a library of ALKON systems Norms. See fig. 1

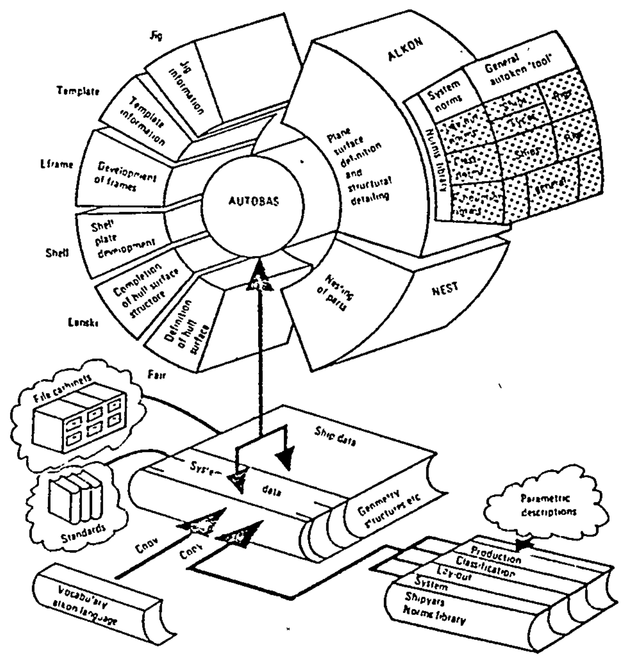


Fig. 1 AUTOKON information system

The "shell structure" modules of AUTOKON-76 have proved to be equally usefull as design" and lofting tools. Actually, these tools do the same job, whether early or late in the process. The benefit to the designer is a matter of his attitude and willingness to use it in his work.

As concerns "internal structure", ALKON and the Systems Norms library may perform lofting in an efficiently way. However, extended use of ALKON in design and production preparation required an enhanced norms library.

A special norms library for extended use on $hips was developed in the Aker Group. This design and production norms library comprises "packages" for a number of purposes:

- o Norms to establish data structures. These are general and we do believe in particular that the production phase data structure is a convention which may be used by all ALKON users. This structure provides the possibility to extract a number of information by drawing norms and list norms.
- O Norms to describe surface and surface structures (plates and stiffening). These packages are mostly "function" and "geographically" oriented: Double bottom, web frames in engine room, etc. They have been run on several ship projects and have been modified for increased generality.
- o Norms to describe types of codes (f.inst. material identification for plates and profiles) and various standards.
- o Drawing norms for design and production drawings, either ordinary block drawings or levels .of drawings reflecting the assembly structure.
- o List norms for generating various types of tabular information, stiffener lists, assembly lists, weight and center of gravity of blocks and sub-assemblies, etc.

The above norm packages mdke,'of course, frequent use of the basic "System Norms" in possession of all ALKON users.

The integrated design and production norm makes it justified-to classify AUTOKON-76 an "information system", .even if the batch technology leaves a lot to be desired as regards communication with the database.

Fig. 2 gives a schematic outline of the various norm packages and their place in the downstream process.

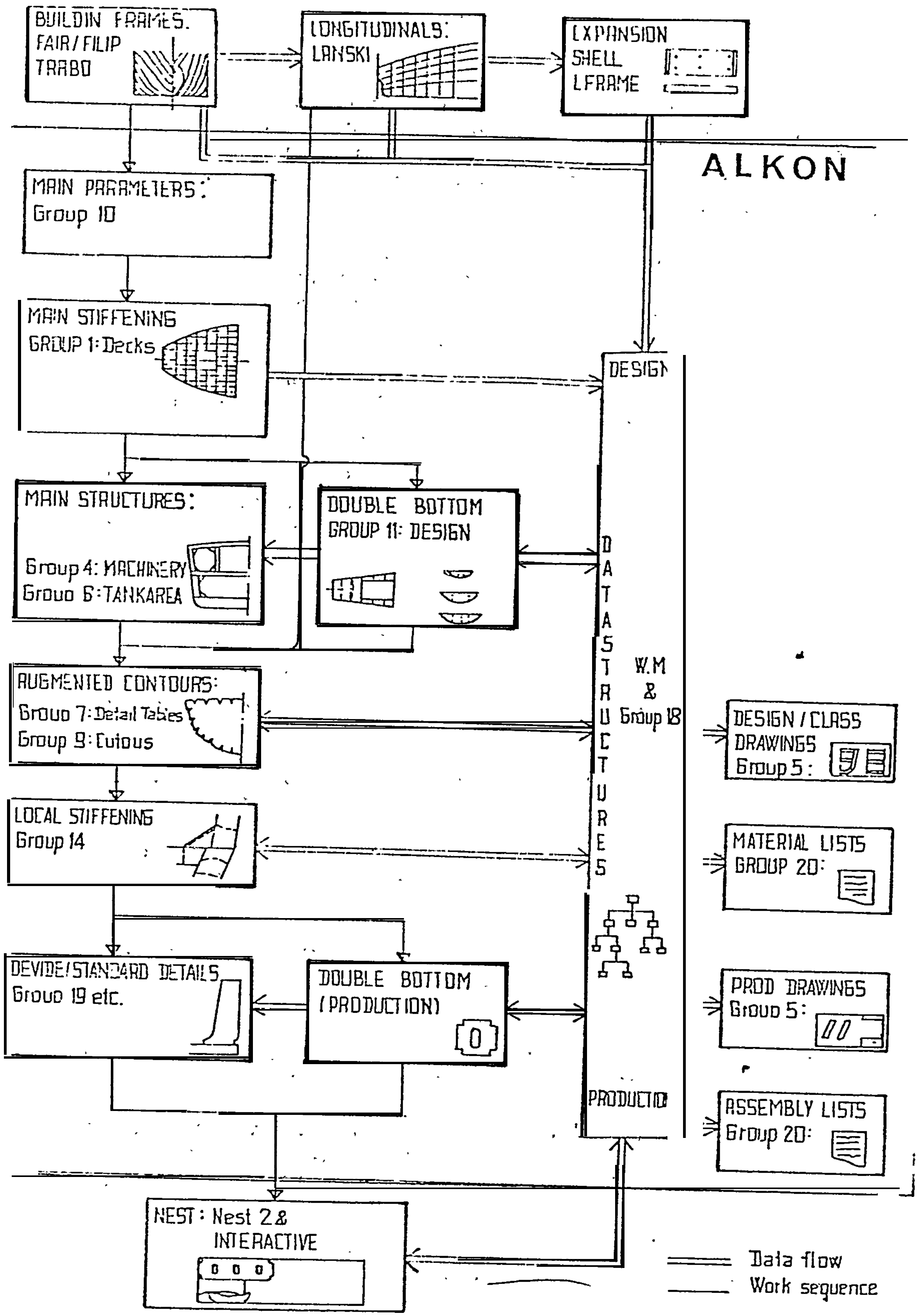


Fig. 2. Structural detailing by AUTOKON.
Schematic flow-diagram showing use of the
various norm "packages" in the down stream process.

It must be admitted that these enchanced norms libraries did not create a break through of ALKON in design.

First of all, the batch technology is not very suitable for convincing the designer that the computer can beat him in making a drawing. Since he has to.face changes, the computer would rather delay him than speed' up his work. He is not willing to accept that even if somebody down stream obviously would bene-fit bv reduced work load and higher accuracy.

' However, notwithstanding batch deficiencies, a great deal of the short comings came from the way ALKON was used, and not from basic limitation in ALKON itself, since it is probably one of the most powerfull geometry compilers available.

- It was not fully apprehended that a very thorough system analysis of the "design process, "formalized procedures and extensive standardization work were fundamental prior to coding an "hierarchy of ALKON norms to cope with design:

- It was not fully understood that norms development of this magnitude was genuine systems development, and that the basic requirements as to user specifications, systems design, systems programming and documentation were valid. No matter whether the programming language,was ALKON.

- The efforts involved and demands on qualifications of parti-cipants were underestimated.

- Lack of time for creating, sufficient "generality" because of pressure from production schedules.

- When the norms were ready, the majority of Aker Group ship contracts were cancelled and efforts turned towards offshore structures.

In spite of above experience,. the norms library has proved useful for the Aker Group. both"for ships and" semi-submersibles.

The power and felxibility ,of.ALKON has really been proved in connection with' unusual constructions such as pipe-trusses (jackets).

At the Aker Verdal yard they managed to increase work preparaticn efficiency considerably by creating a special norms library for jacket design, fig. 3.

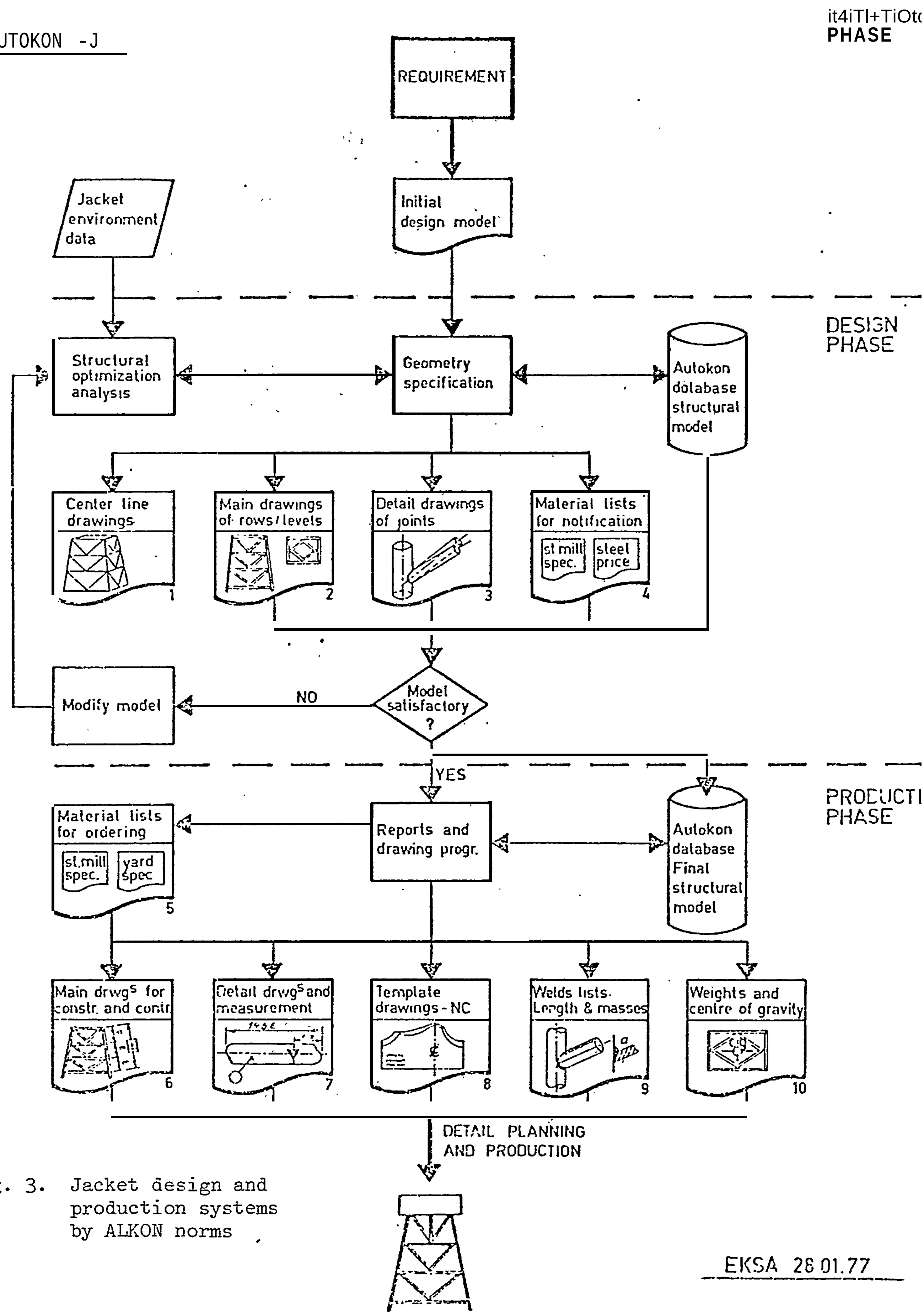


Fig. 3. Jacket design and production systems by ALKON norms

After a few weeks the first norm were actually used in production preparation. The norm which generates the template for the cutting of truss connections (activity 8) produces a template in 20 - 30 minutes. Manually a good craftsman" would manage 2 to 3 templates a day.

The accuracy obtained using a numerical method was far better and a substantial saving and better product quality was registered. Let us just mention that in 12 leg Jacket which has been built there were 560 such templates. The tubes in the Jacket had a diameter of up to 1.5 meters and a plate thickness of up to 70 millimeters. The actual truss-connections may be very complex often with tubes intersecting eccentrically.

2. INTERFACING THE PRESENT AND FUTURE AUTOKON

3 years ago it was decided to develop a new AUTOKON system for the 1980-ies. Based on the requirements previously set forth and the knowledge of short comings .of present AUTOKON, it is obvious that Interactive AUTOKON had to be established on an entirely new concept.

The development project started with AUTONEST, the new operational interactive nesting system, and has another 3 - 4 years to go. However, since short term results was demanded, the goal is to provide the user with the best total system throughout the development period until the present AUTOKON is finally replaced

Hence, it is not the intention to throw the present AUTOKON overboard. On the contrary it represents a powerfull and flexible tool that has reached a remarkably high operational reliability.

Our development policy is to get short term results which can extend the present. AUTOKON usage at the same time as being integrated parts of the new system.

We believe this development policy is to the.advantage of all present AUTOKON-76 users, since it will allow them to change gradually towards the full Interactive AUTOKON if desired.

3. INTERACTIVE AUTOKON (IA)

Fig. 4 is a description of IA in terms of functions and/or applications to be covered. The figure reflects the demands on modern technical information system previously mentioned and demonstrates the central position of the product model as a source of information. In fact, the figure is valid for all technical information systems covering different engineering fields (steel, piping, electrical, etc.)

It may be of interest to compare these functions with the modules of AUTOKON-76. It should be kept in mind that all functions are based on use of interactive graphics, hence this is not particelarly mentioned under each item.

Product model building.

This function is perhaps the most vital since it is the beginning of the process. Model building incorporates separate topological and geometrical description as well as data on functional requirements, material properties, ete. The product model includes both a design oriented (functional) structure and a production oriented structure. A particular part belongs to deck A at the same time being included in subassembly B.

Compared to AUTOKON-76 this function includes FAIR, LANSKI, SHELL, ALKON and in partiicular the enhanced norms Library.

Product documentation

This f unction offer powerfull facilities for verification, and manipulation bf product in informationin terms of drawings, tables, etc.. It means a significant diference from the batch tehnology, which is rather inflexible as regards composition, presentations etc. other than "programmed". It represents the "draftsman" and is really a reflection of the fact that there are many ways to visualize and verify a Product.

In AUTOKON-76 the drawing/printing functions are found inherence in all program modules and in the enchanced norms library.

In IA this functidn is more a "general drafting tool" which also have the responsibility to administrate the document file.

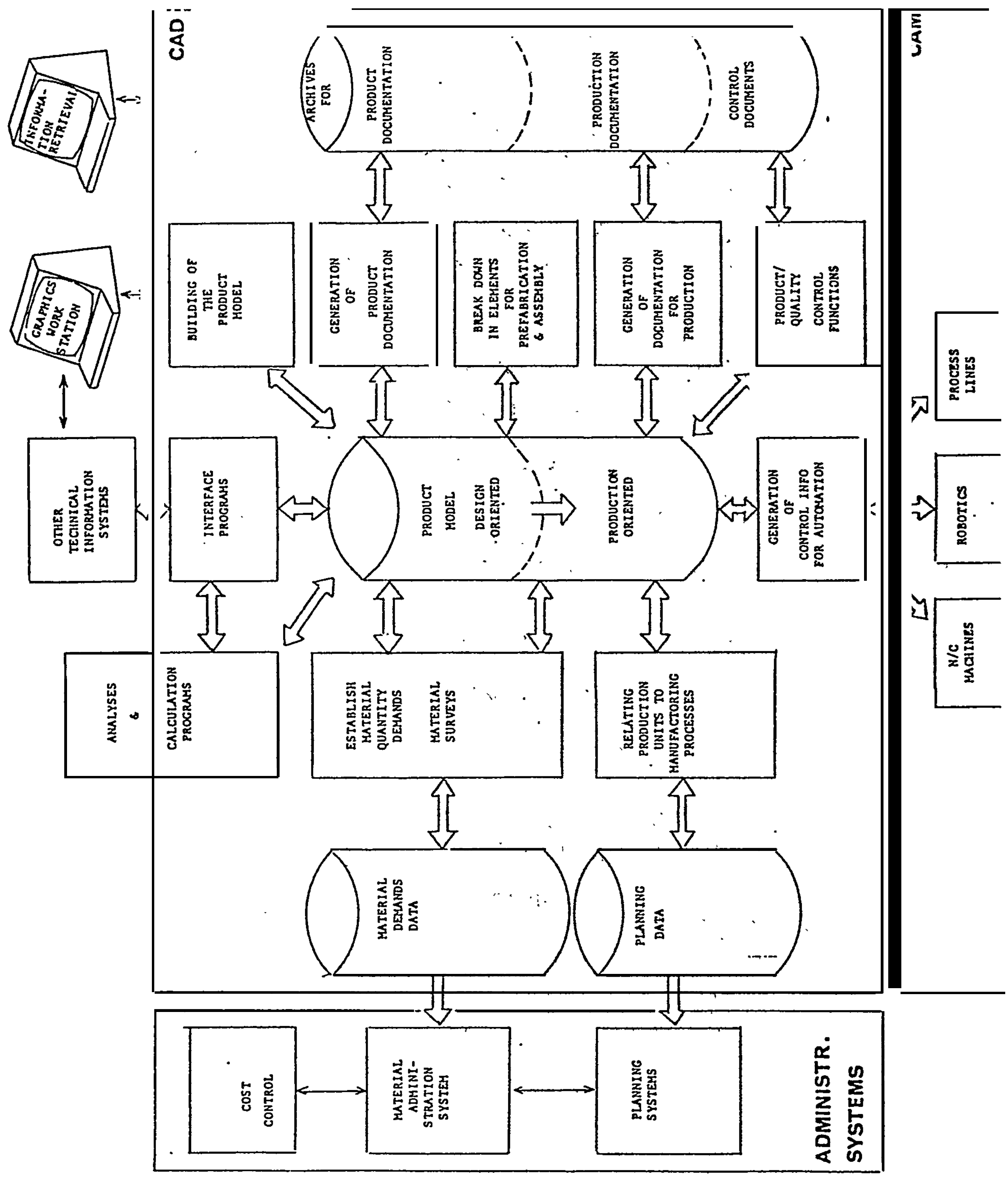


Fig. 4. Interactive AUTOKON, outline of main functions

3.3 Break down of production manufacturing elements

Starting from the design product model, this process will be more or less automatic. The efforts cbnsumed will be drastically reduced compared with traditional "part coding" which will almist disappear.

Based on this production oriented product model, generation and manipulation of work shop documentation will be made in the same way and by the same tools as in 3.2.

Comparing with AUTOKON-76; this function incorporate features found in the programs LANSKI, 0SHELL, LFRAME, TEMPLATE, JIG, ALKON and.NEST.

3.4 Product/quality control functions

Such facilities are non–existent in present AUTOKON-76.

The new functions are generally concerned with providing special drawings convenient for control and for establishing "as built'" information+ The second major objective is to tie-up all kind of testing and certificate data'to the product model and admin~-strate the cohtrol documentation.

3.5" Generation of control info for ,shop automation

This function is"the, link to CAM. Since the product model contains all information regarding both finished parts and finished product, it is a matter of post processing such data to control information.

More important is the fact that the product model contains infcrma-tion to control robots f.inst. *welding* robots. The potential exists for sibilating welding procedures.

In this respect IA opens up for a wide range of CAM applications, compared to AUTOKON-76, which is limited to N/C data in SHELL and NEST .

3.6 Material demands

AUTOKON-76 offers little in this respect, especially in early stage for material ordering unless the enhanced norm library is used. In this respect IA will mean a great' step forward. This function will maintain a full 1:1 correspondance between engineering and material status, 'keeping track of consequences of design changes on materials'specification vice versa. A variety of material summaries will be available and the material demand,file is the source of information for the material administration system.

3.7 Relating product units to manufacturing

This function will provide facilities for calculations for processing times (cutting; welding etc.) and for relating parts and assemblies to shop equipment and production flow to ease production planning and control.. Of even more potential value is the possibility of interactive simulation to investigate production 'methods.

3.8 Interface to calculation and analyses programs

Typical examples are hydrostatics" hydrodynamics, structural analyses. These programs may either be inteegrated directly with the product model (f.inst.' hydrostatics) or work on derived (simplified) design models,such as, in the case of generating meshes for finite elements calculations.

3.9 Communication with other technical systems

The most typical example is the need for structural information as "background" when doing piping layout. Or vice versa, the piping information system w1lI. provide exact position of all pipe penetrations in structures.

The outline of functions 31. - 3.9 above is equally valid for other technical information- systems..

4. BRIEF DESCRIPTION OF INTERACTIVE AUTOKON "MODULES"

4.1 General on terminology"

In AUTOKON-.76 a module is a program, performing a well defined task. Tne module structure is rather rigid and is self contained with output routines .

In the previous section the 1A functions were briefly described. A function may contain a number of applications or procedures which make up the totality of jobs or tasks either from an organizational point of view or because it is a convenient and natural way to group tasks.

Example: Material take-off" and making bill of materials for steel plates and bars.

A certain procedure may be required and incorporated in different responsibilities at different points of time.

F.inst., the interactive nesting system AUTONEST cotains 3 clearly distinguishible and (from a systems point of view) separate phases: preparation, lay-out (nesting) and cut/mark sequencing. Together these,3 procedures cover the total task to complete nesting as a loft function with the ultimate' goal to generate a N/C tape.

On the other hand, the lay-out (nesting) procedure should be available to the material take-off' man who is working several months earlier than the loftsman. In other words, the same procedure may appear in different functions. A procedure may be small or large in terms of EDP programs. The basic level is an action routine governed by commands.

An efficient command processor is avaiiable to link,together action routines to higher level procedures, procedures organized into tasks and tasks organized into functions.

From a systems point of view, therefore, IA must be regarded as a tool kit, a big library of basic tools (action routines) which may be organized as described above.

The "user manual" as we know it, will be reflecting how to Perform a task by means of a particular collection of action routines. The command processor allows the user to switch quickly from one procedure to another, even if he may see each procedure as "fixed".

Therefore, a module does not have the same meaning in IA as in AUTOKON-76 . However, certain names have been selected to express functions as a total or to signify procedures or applications as part of functions. These names may change, so may also the "contents" relative to the name.

Due to the relatively long term period of the IA development, the specifications are not of equal degree of detail, depending on the priority given to them.

4.2 *Names of* functions and applications

Fig. 5 is the.previous.fig. 4 supplied with names presently given to, either functions or. procedures/applications in IA.

The main functions are covered by

AUTOMODL	Design and production oriented model building including break down of product structure for prefabrication and assembly purpose.
AUTODRAW	General drafting tool for visualization of product model and for generation of design and production documentation,
AUTOCONT	Serving product/quality control functions
AUTOPROD	Providing link between CAD and CAM. Generation control information for shop,automation.
AUTOPLAN	Relating product units to manufacturing lines and processes.
AUTOSPEC	Serving the material take-off function

Within the functions fig. 5 shows the following procedures or applications , with a circumscribed name:

AUTOPART	The "bottom level" of AUTOMODL, providing a subset for interactively generating parts or dividing or modifying ALKON parts from AUTOKON--76.
AUTONEST	Interactive parts nesting generating N/C tapes for nested sheets.
AUTODRAW(S)	Subset of AUTODRAW intended for generation and manipulation of shopdrawings with a short term goal to use AUTOKON-76 data.

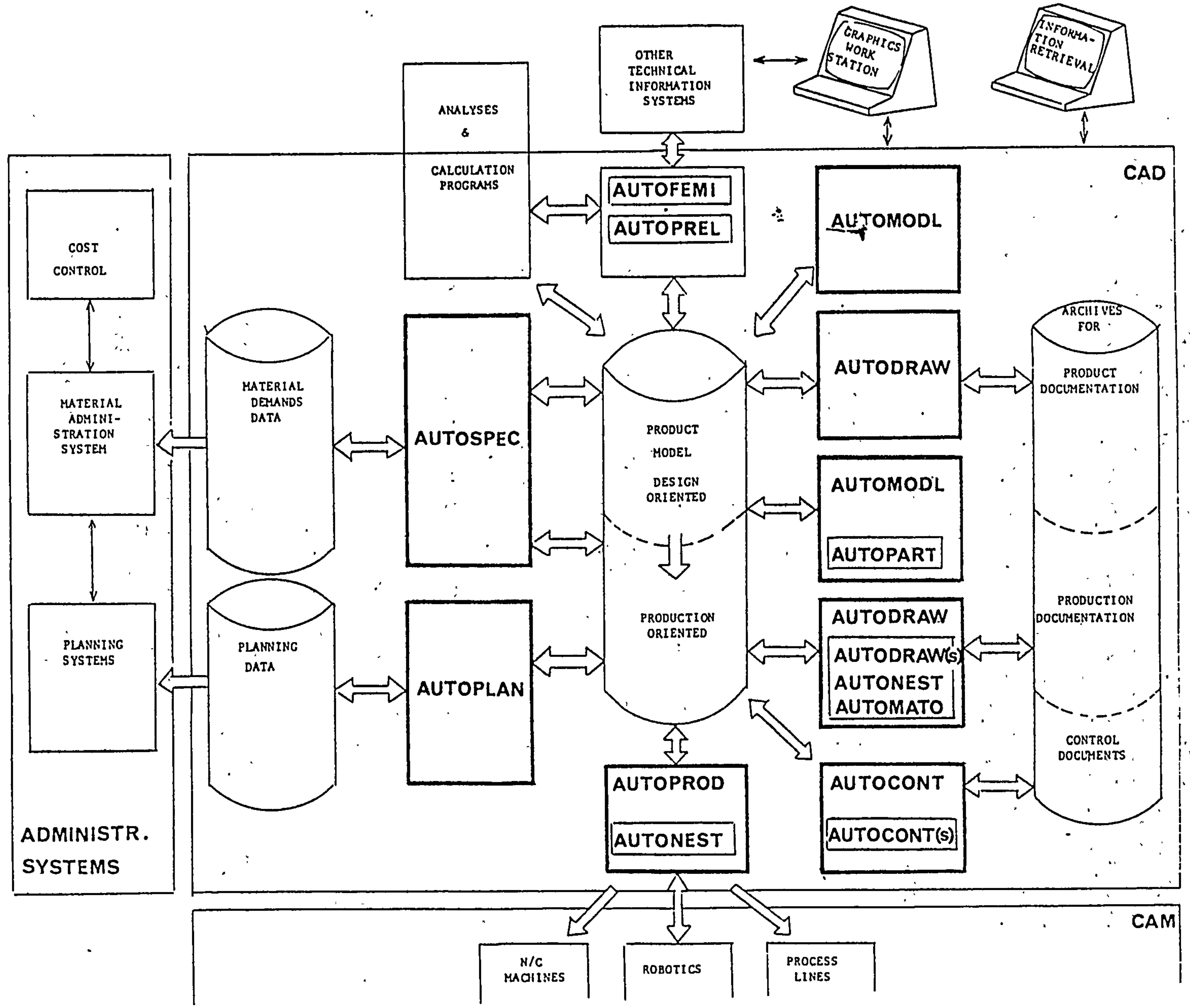


Fig. 5. Interactive AUTOKON, names of functions and applications

AUTOMATO — Subset of AUTODRAW to generate and edit various kinds of shop drawings for collar plates, marking of stiffeners, stiffener lists, etc. To some extent AUTOMATO will serve material take off function also.

AUTOCONT(S) — Subset with the limited objective of providing special control drawings for follow-up during construction.

AUTOPART, AUTONEST, AUTODRAW(S), AUTOMATO and AUTOCONT(S), represent the short term results of the IA developments.

By communication with the AUTOKON-76 database, they provide effficient interactive tools to manipulate A-76 data in a way that cannot be done within A-76 itself. This connection is indicated in fig. 6. They assume all "shell modules" of A-76 to be used., Further, the more extensively ALKON and norms libraries are used to build up the structure (the A-76 product model), the more information is available for further manipulation by the interactive procedures.

At the same time, as already pointed out, the same procedures are subsets of the final IA system, which should be seen from fig. 7.

In this way, the development policy expressed in section 3 is implemented by offering the AUTOKON user the best total system throughout the development period. These short term "results efficiently attack the product-ion preparation area, which account for some 50% of the engineering hours in handling of steel structures.

In addition to above mentioned procedures, fig. 5 do also include 2 interface programs to analysis, programs.

AUTOPREL : Making the IA product model available for a net PRELIKON system, planned to be developed in cooperation between SIAG and the other Norwegian parties.

AUTOFEMI : Generating a derived design model for providing meshes to finite element calculations.

In the following figures some of the above mentiofied functions or applications are briefly outlined in a simple, pictorial form which hopefully is self-explanatory, see fig. 8, and ***succeeding figures..***

However, as regards AUTONEST, AUTOPART and AUTODRAW, more details are given below.

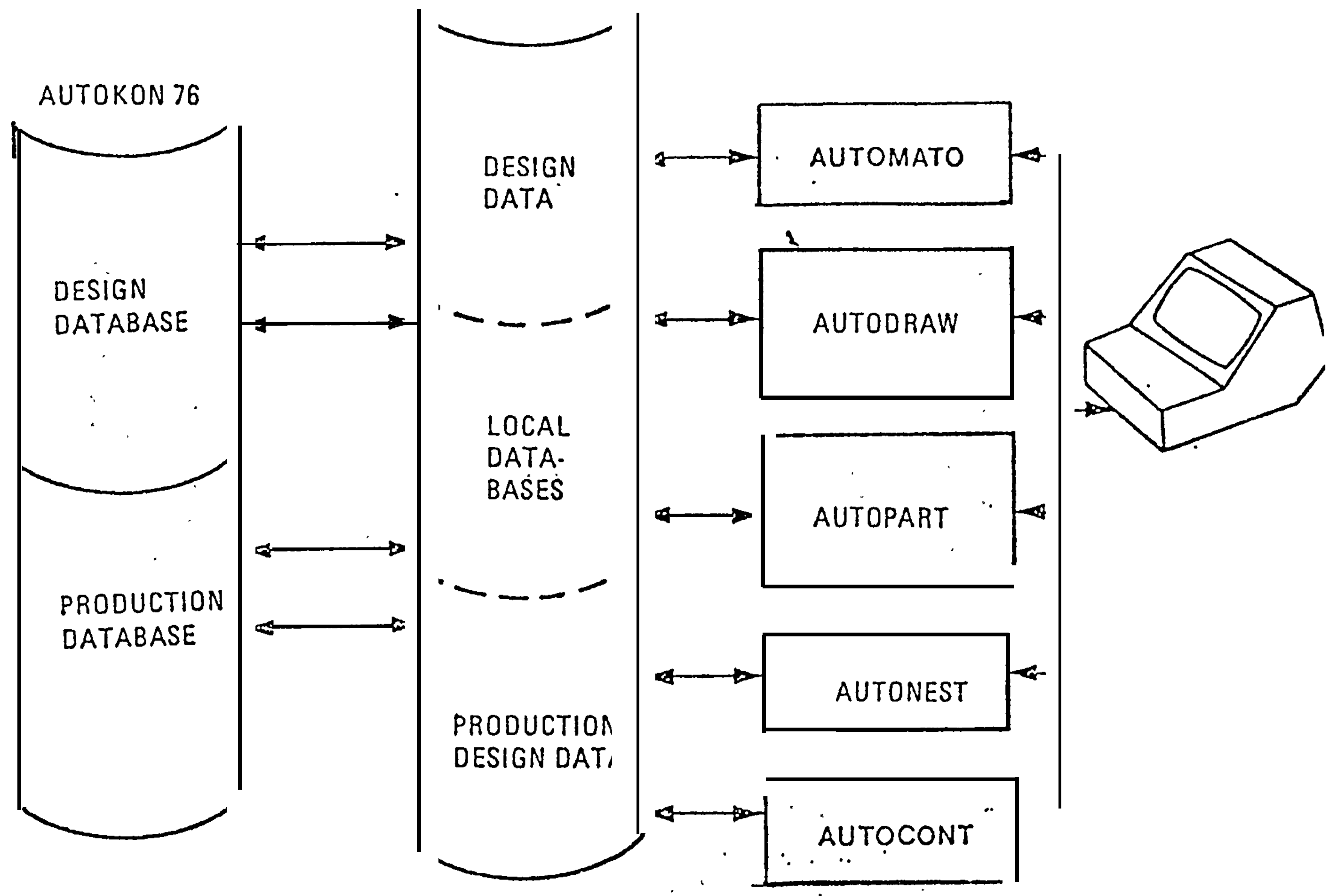


Fig. 6. Communications between AUTOKON-76 and certain applications in Ineractive AUTOKON

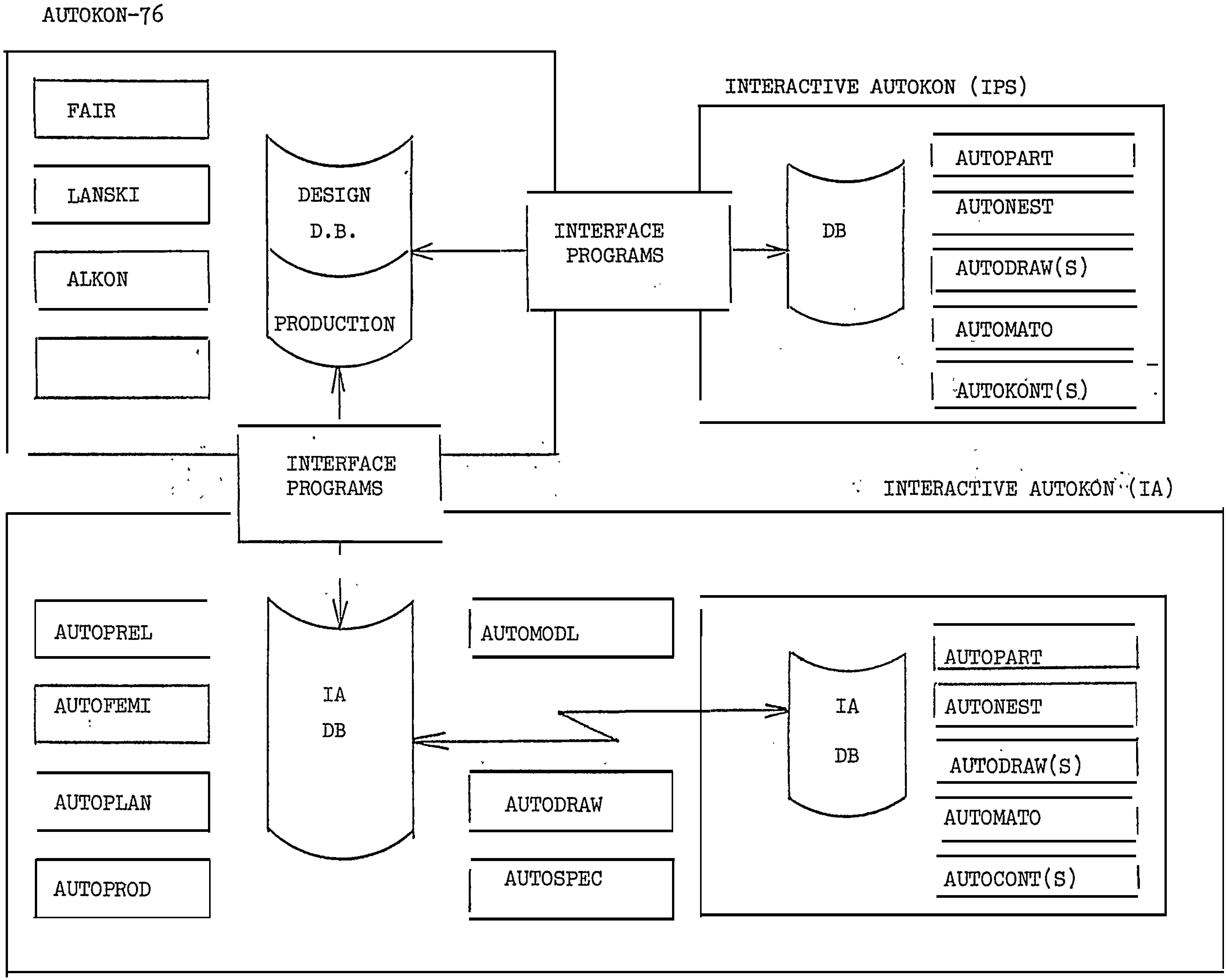


Fig. 7. AUTOKON-76 linked to interactive AUTOKON applications from ongoing developments

4.3 AUTONEST

This application is briefly described in the attached brochure. AUTONEST has been in operation for more than one year in Aker and in Verolme Rozenburg yard in Holland. We beleive it passed the acid test at Verolme and we quote from the paper given at the AUC-78 meeting (they are using 2 screens simultaneously):

> "Figures about savings in time and money, comparing batch and interactive versions, are very difficult to caluculate. VDSM traditionally pays very much attention to nested formats; Cutting combination, use of more torches, heat distortion and edge preparation does influence the time needed for the nesting procedure; it's our yard-policy, which has to be followed. Performing this sometimes elaborative way of nesting interactively did show a substantional reduction of manhours and calendertime, even in spite of all the problems which have been mentioned.
>
> Roughly, using 1 - 2 manhours, in 2 - 3 days for a plate filled with 4 - 12 parts in batch, now interactively 3 - 5 plates of this kind can be done in about 1 hour. (Max. performance 12 formats in 1 hour).
>
> Additionally, one format filled with 67 parts, some of these with inner contour, did take slightly more than half a day, against 2 - 3 days in the old way."

AUTONEST operational on a NORD 10/S computer with a minimum core requirement of 64 K words (16 bits).

4.4 AUTOPART

As already mentioned, AUTOPART is a subset of AUTOMODL, with the following features included.

Basic part coding:

- o Basic geometrical definition (SL, CIR, etc.)
- o Defining and referring to predefined contours
- o Treating standards (cutout, holes, etc.)

Advanced part coding:

- o Split contours
- o Editing contours
- o Generate and refer to parallel contours
- o Divide surface units (parts)

Model building

o Definition of design and production units.

In fact AUTOPART may be considered also as a stand alone part coding system just as ALKON basic.

4.5 AUTODRAW

The purpose of AUTODRAW is to provide to following facilities.

a. Verification of:

- o Contours
- o Tables
- o Text

b. Generation of drawings:

- o "Composition"-lay-out
- o Completion of drawings with

  Text
  Symbols
  Dimension lines
  Identifications/references
  Applying drawing "standards"

- o Generate other veiws

  Orthogonal
  Perspective
  Axionometric
  Isometric
  Removal of hidden lines

c. Build and administrate the documentation file:

The subset of AUTODRAW will include a), parts og b) and c) as far as shopdrawings are concerned.

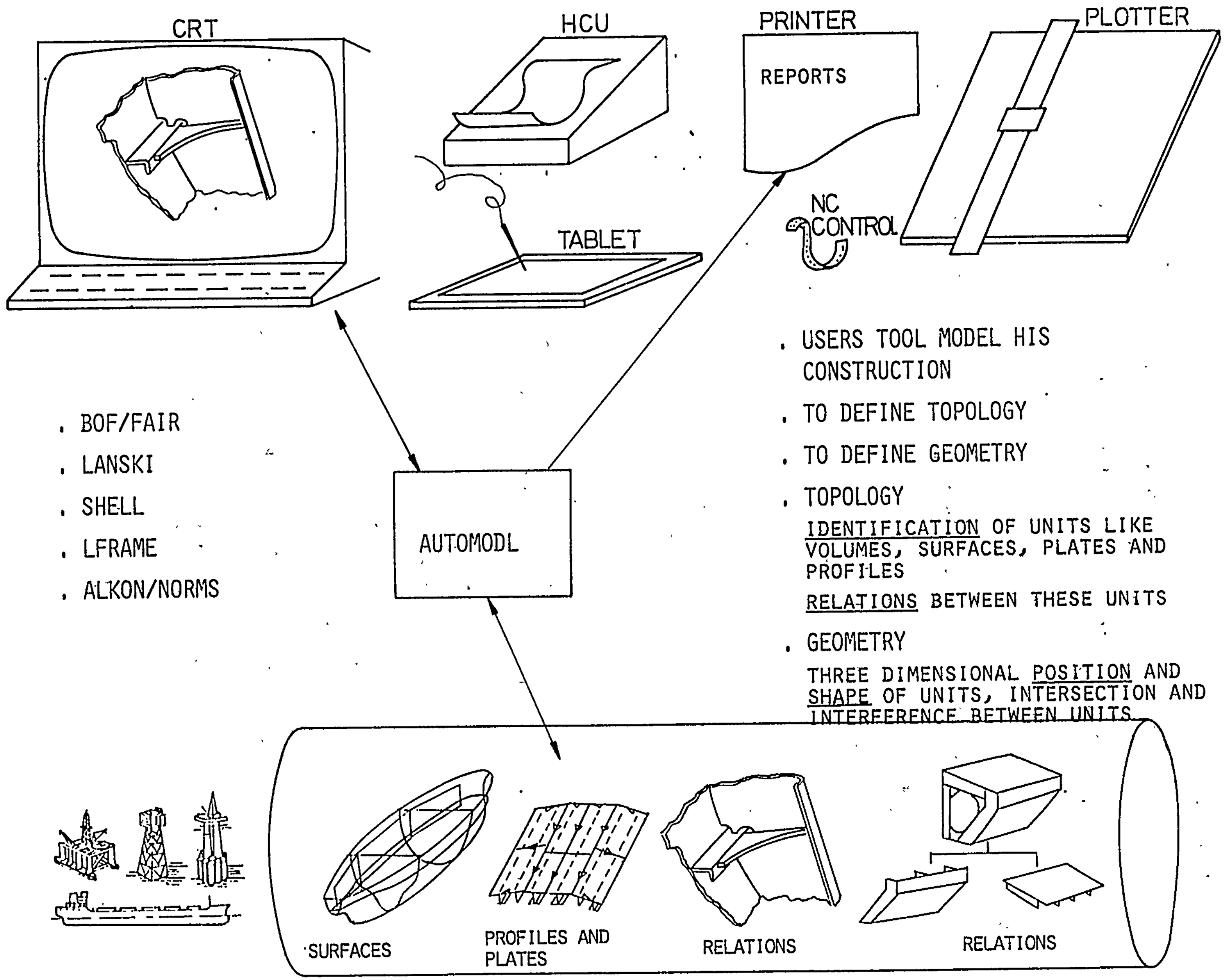

CRT
HCU
PRINTER
REPORTS
PLOTTER
TABLET
NC
CONTROL
. BOF/FAIR
. LANSKI
. SHELL
. LFRAME
. ALKON/NORMS
AUTOMODL
. USERS TOOL MODEL HIS CONSTRUCTION
. TO DEFINE TOPOLOGY
. TO DEFINE GEOMETRY
. TOPOLOGY
IDENTIFICATION OF UNITS LIKE VOLUMES, SURFACES, PLATES AND PROFILES
RELATIONS BETWEEN THESE UNITS
. GEOMETRY
THREE DIMENSIONAL POSITION AND SHAPE OF UNITS, INTERSECTION AND INTERFERENCE BETWEEN UNITS
SURFACES
PROFILES AND PLATES
RELATIONS
RELATIONS

Fig. 8.

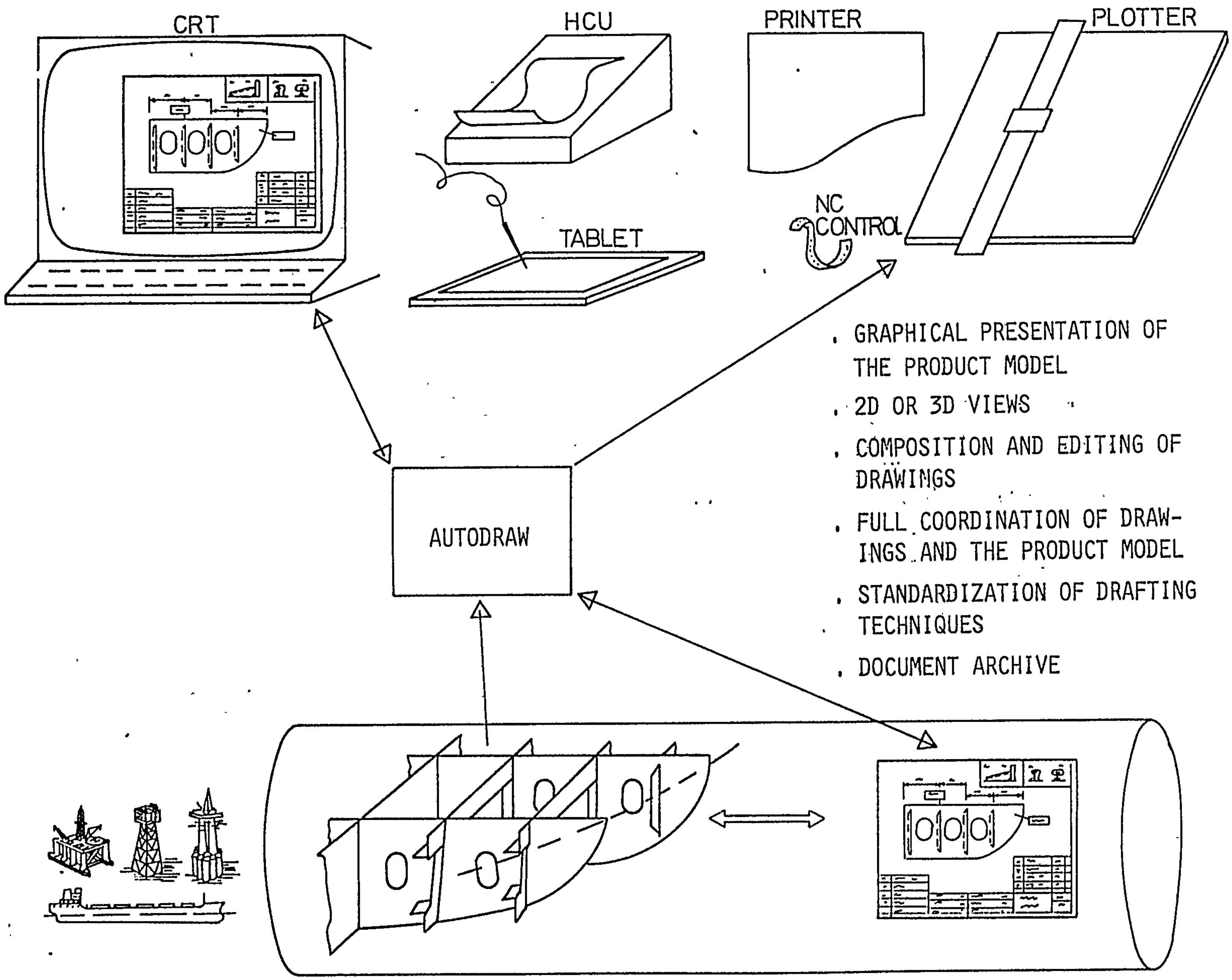
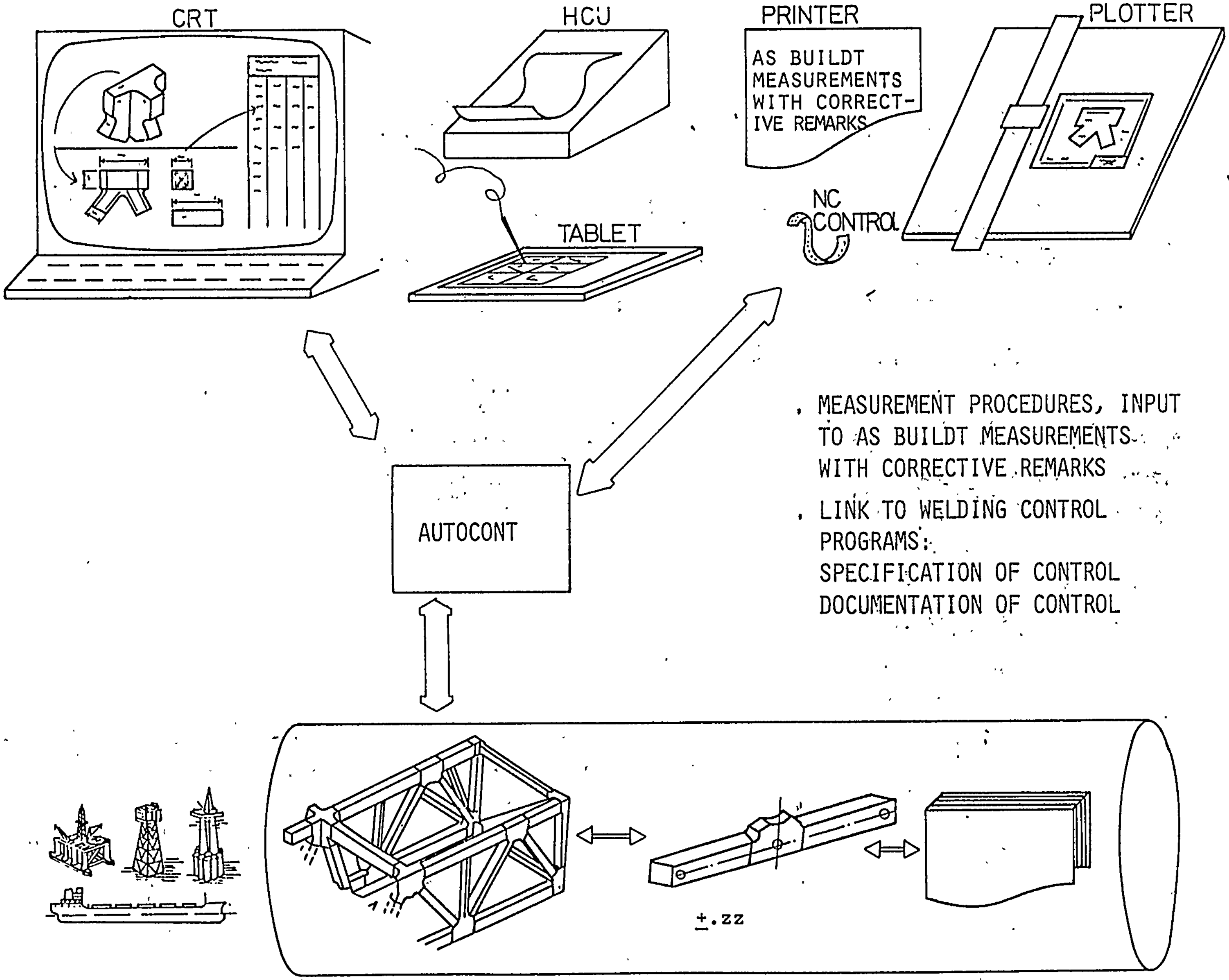

CRT
HCU
PRINTER
PLOTTER
TABLET
NC CONTROL
AUTODRAW
. GRAPHICAL PRESENTATION OF THE PRODUCT MODEL
. 2D OR 3D VIEWS
. COMPOSITION AND EDITING OF DRAWINGS
. FULL COORDINATION OF DRAWINGS AND THE PRODUCT MODEL
. STANDARDIZATION OF DRAFTING TECHNIQUES
. DOCUMENT ARCHIVE

Fig. 9.



INTERACTIVE AUTOKON

Fig. 10.

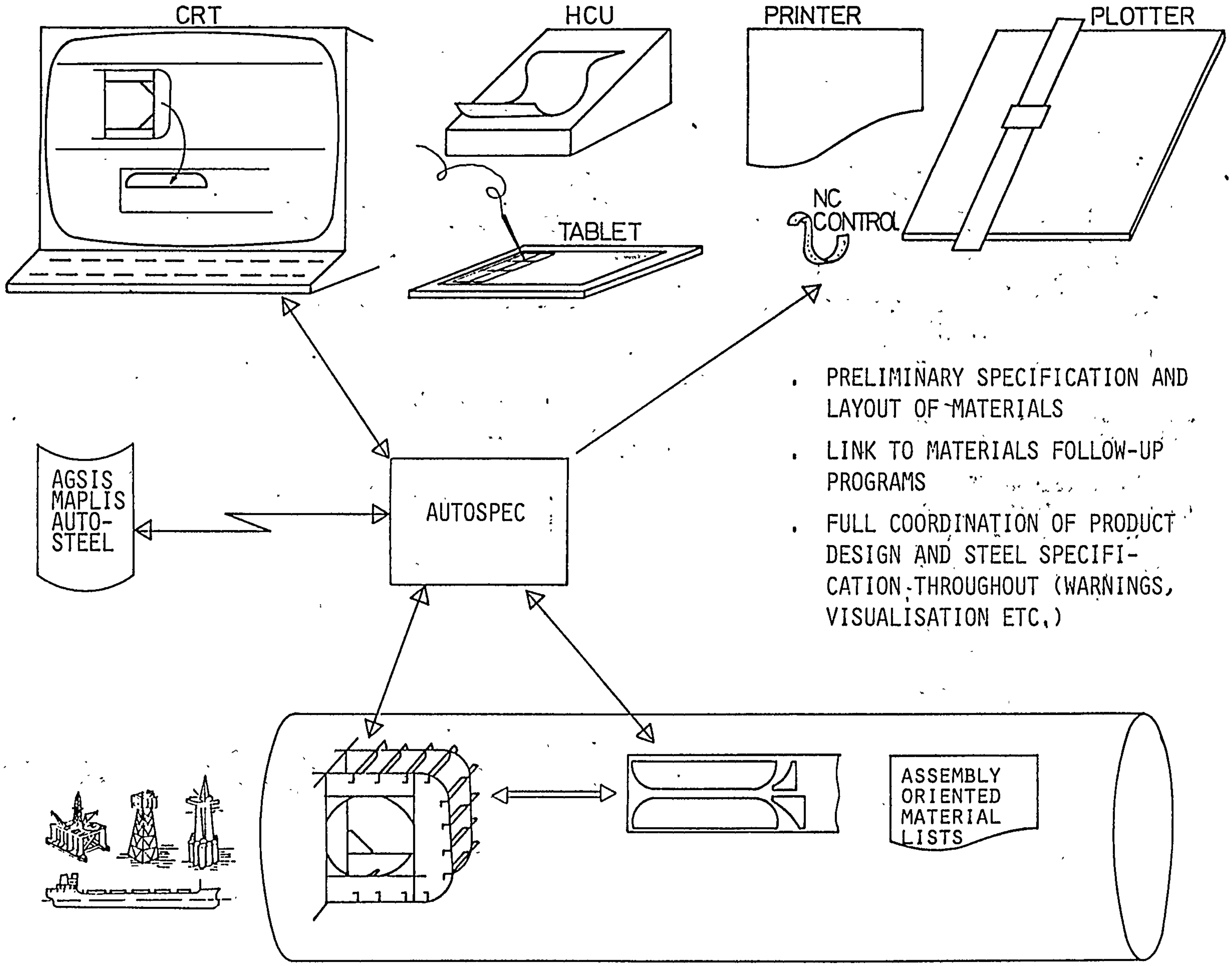
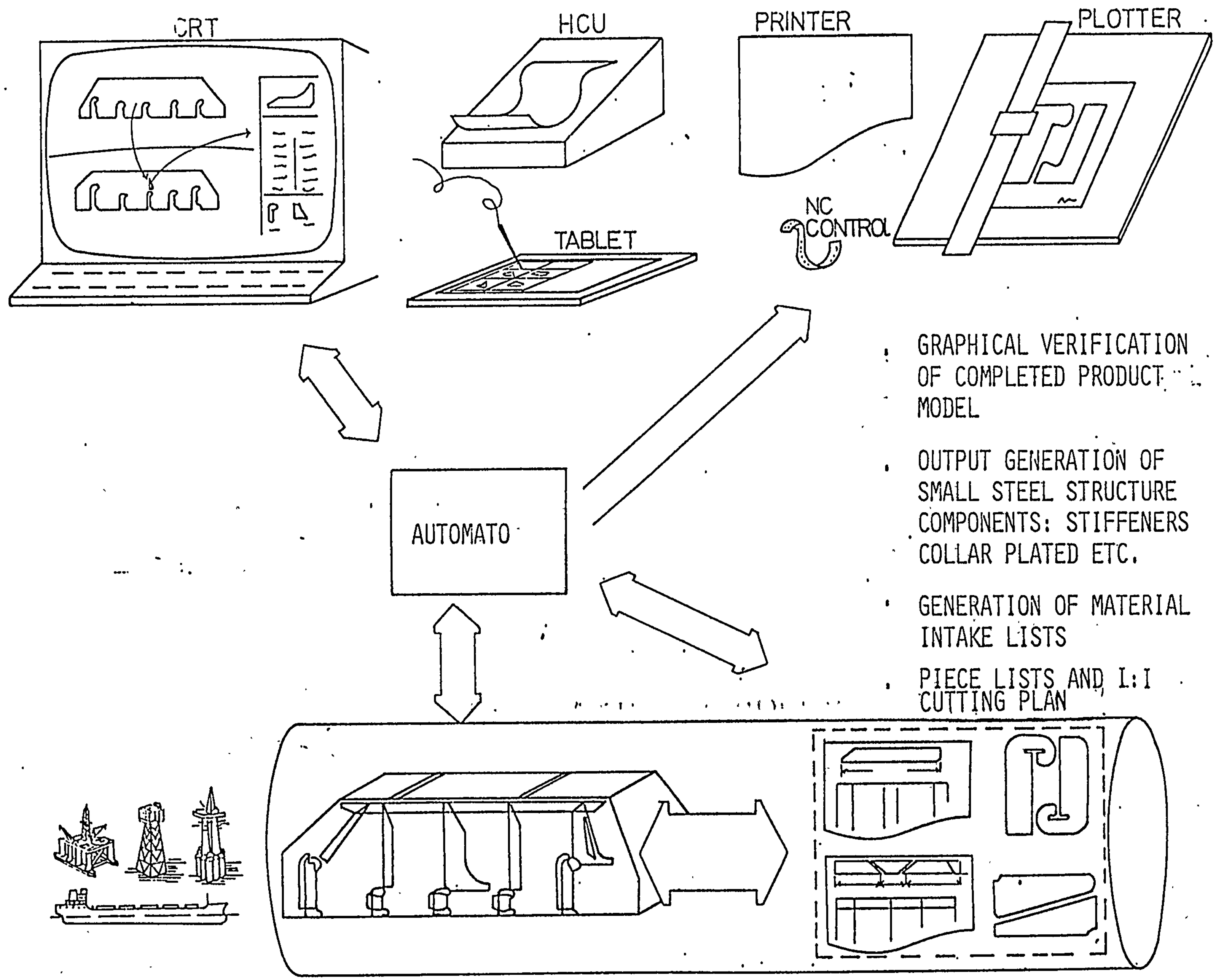

CRT
HCU
PRINTER
PLOTTER
TABLET
NC CONTROL
AGSIS
MAPLIS
AUTO-
STEEL
AUTOSPEC
. PRELIMINARY SPECIFICATION AND LAYOUT OF MATERIALS
. LINK TO MATERIALS FOLLOW-UP PROGRAMS
. FULL COORDINATION OF PRODUCT DESIGN AND STEEL SPECIFICATION THROUGHOUT (WARNINGS, VISUALISATION ETC.)
ASSEMBLY
ORIENTED
MATERIAL
LISTS

Fig. 11.



CRT
HCU
PRINTER
PLOTTER
TABLET
NC CONTROL
AUTOMATO
GRAPHICAL VERIFICATION OF COMPLETED PRODUCT MODEL
OUTPUT GENERATION OF SMALL STEEL STRUCTURE COMPONENTS: STIFFENERS COLLAR PLATED ETC.
GENERATION OF MATERIAL INTAKE LISTS
PIECE LISTS AND I:I CUTTING PLAN

Fig. 12.

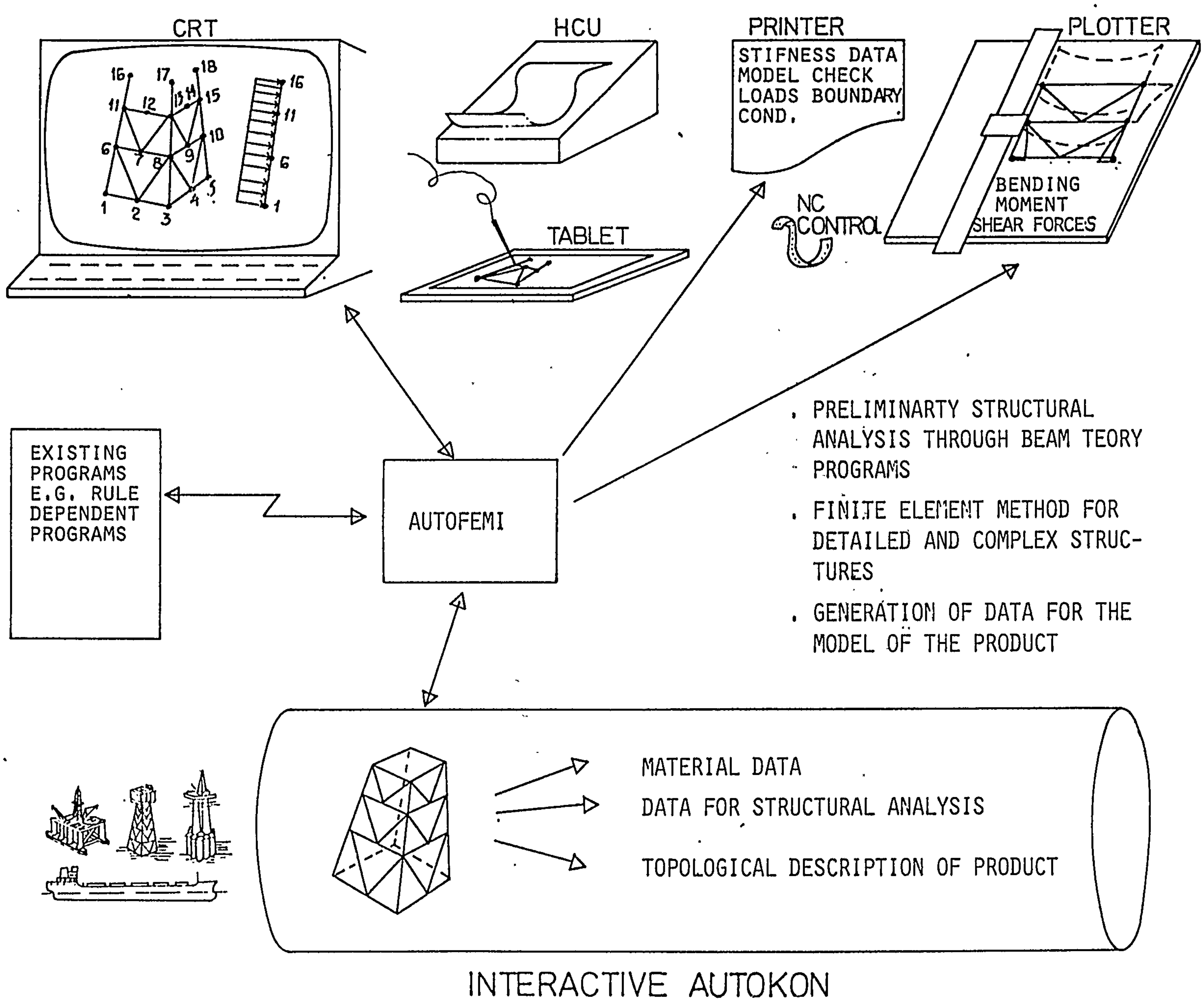

CRT
HCU
PRINTER
PLOTTER
STIFNESS DATA
MODEL CHECK
LOADS BOUNDARY
COND.
TABLET
NC
CONTROL
BENDING
MOMENT
SHEAR FORCES
EXISTING
PROGRAMS
E.G. RULE
DEPENDENT
PROGRAMS
AUTOFEMI
. PRELIMINARTY STRUCTURAL ANALYSIS THROUGH BEAM TEORY PROGRAMS
. FINITE ELEMENT METHOD FOR DETAILED AND COMPLEX STRUCTURES
. GENERATION OF DATA FOR THE MODEL OF THE PRODUCT
MATERIAL DATA
DATA FOR STRUCTURAL ANALYSIS
TOPOLOGICAL DESCRIPTION OF PRODUCT
INTERACTIVE AUTOKON

Fig. 13.

5. DEVELOPMENT SCHEDULE

AUTONEST is operational and available.

The other applications (subsets) shown in fig. 6.

AUTOPART
AUTODRAW(S)
AUTOMATO
AUTOCONT(S)

are scheduled for completion in a NORD-10/S version within medio 1979 and expected to be available for release utlimo 1979.

The remaining functions are partly developed in parallel to the extent needed for coordination, but are treated in the following order of priority:

AUTOMODL
AUTODRAW (enhanced version)
AUTOSPEC
AUTOCONT (enhanced version)
AUTOPREL
AUTOFEMI
AUTOPROD
AUTOPLAN

The entire development program is scheduled to be completed in 1982.

PRESENT SIAG-DEVELOPMENTS

PART 3

A U T O F I T

Presented by
P.F. Sørensen, SRS

1. INTRODUCTION

AUTOFIT is an abbreviation for automated outfitting.

AUTOFIT is a computer based technical information for piping design and production engineering. The system includes all main functions such as design, lay-out, work preparation and material take off. AUTOFIT provides a "product model" which is instrumental as a source of information to other tasks or functions: analyses, planning, shop automation and not to forget other engineering functions.

AUTOFIT as a system concept is common for all outfitting problems of similar nature, such as piping, wiring and ducting, even if implemented only for piping and instrumentation.

AUTOFIT is basically independent of product which makes it equally applicable to any piping system irrespective of purpose: ships, offshore vessels, petrochemical and chemical plants, whether off-shore or on-shore.

Communications between the user and the AUTOFIT information system is based on extensive use of interactive graphics techniques.

2. OUTLINE OF AUTOFIT

Fig. A1 shows the major tasks involved in the total process of piping design and production engineering, including material take-off.

Done in the conventional way, these tasks may be divided into three rather logical phases:

- <u>functional design</u>, resulting in a P & I diagram with all associated information in the form of drawings, lists etc.

- <u>lay-out design</u>, using either orthogonal arrangement drawings or building a small scale physical model, both visulizing the final arrangement.

  Both phases involves a variety of calculations and analyses.

- <u>preparation of work shop documentation</u>, such as isometrics, price drawings, material lists, etc.

In parallel with these tasks, the designer has to do material take-off.

The figure indicates which tasks of conventional process are included in the computerization. It appears that design of flow diagrams or systems schematics is assumed to be done manually.

Fig. A2 shows a general view of AUTOFIT, divided into main functions or sub systems, which correspond very closely to the sub-division of work just described.

DIAGRAM	:	covering functional design
LAYOUT	:	covering layout design
ISOMET	:	for workshop documentation
MTO	:	for material take-off
CALCUL	:	covering analyses and calculations

A brief description of each subsystem is given below together with the status.

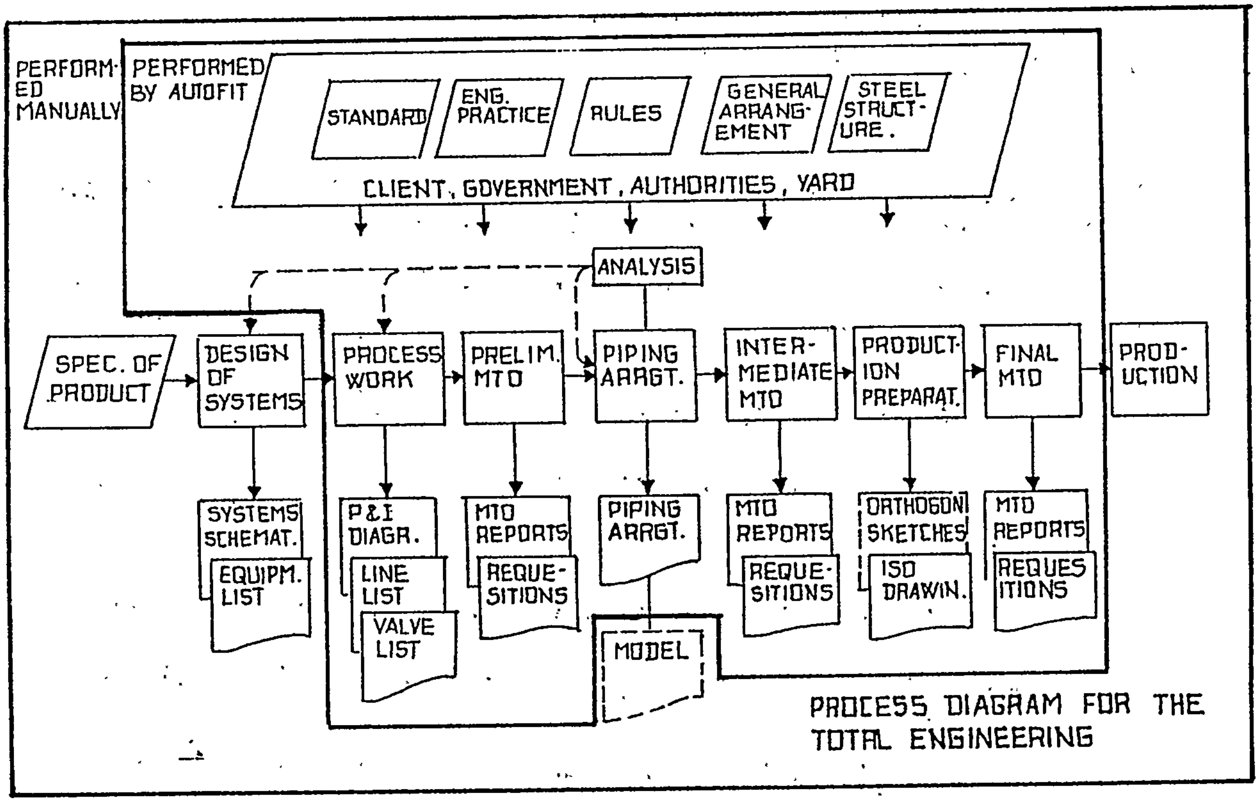

PERFORMED MANUALLY
PERFORMED BY AUTOFIT
STANDARD
ENG. PRACTICE
RULES
GENERAL ARRANGEMENT
STEEL STRUCTURE.
CLIENT, GOVERNMENT, AUTHORITIES, YARD
ANALYSIS
SPEC. OF PRODUCT
DESIGN OF SYSTEMS
PROCESS WORK
PRELIM. MTO
PIPING ARRGT.
INTERMEDIATE MTO
PRODUCTION PREPARAT.
FINAL MTO
PRODUCTION
SYSTEMS SCHEMAT.
EQUIPM. LIST
P&I DIAGR.
LINE LIST
VALVE LIST
MTO REPORTS
REQUESITIONS
PIPING ARRGT.
MODEL
MTO REPORTS
REQUESITIONS
ORTHOGON SKETCHES
ISO DRAWIN.
MTO REPORTS
REQUESITIONS
PROCESS DIAGRAM FOR THE TOTAL ENGINEERING

Fig. A1

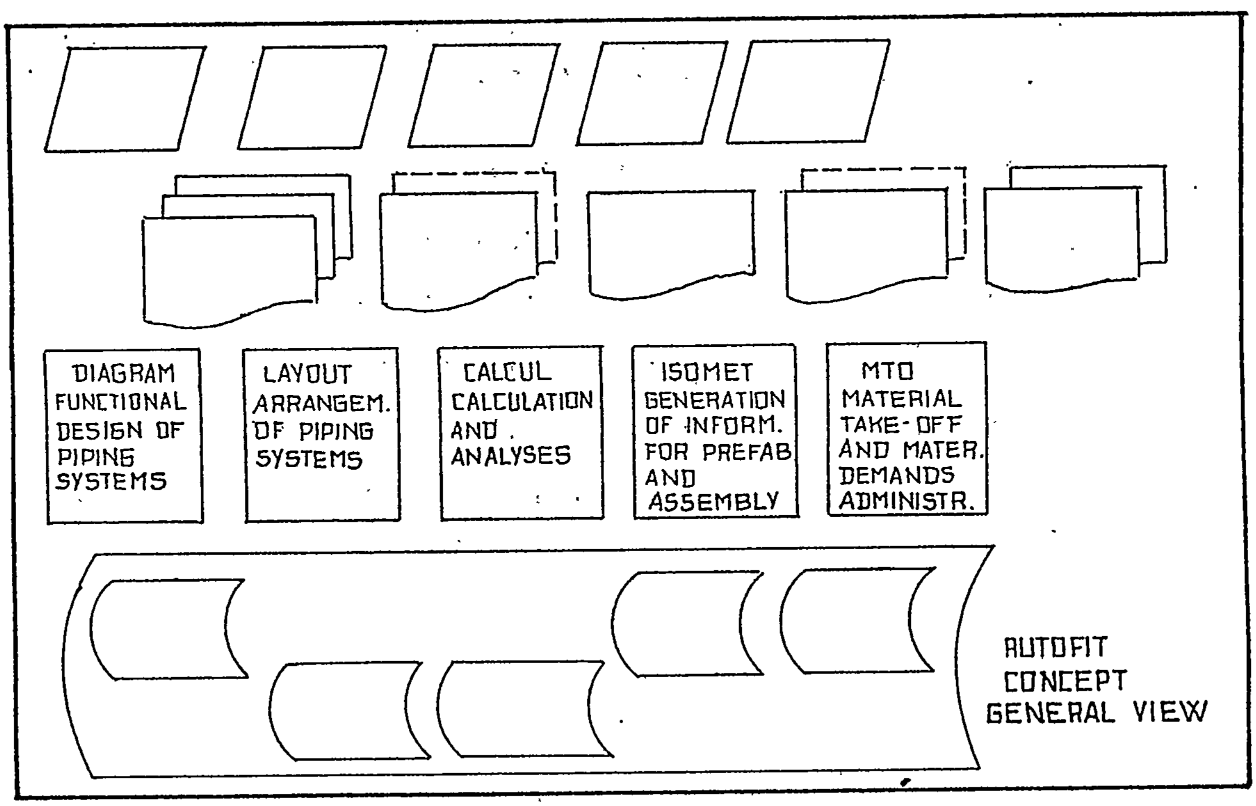


DIAGRAM FUNCTIONAL DESIGN OF PIPING SYSTEMS
LAYOUT ARRANGEM. OF PIPING SYSTEMS
CALCUL CALCULATION AND ANALYSES
ISOMET GENERATION OF INFORM. FOR PREFAB AND ASSEMBLY
MTO MATERIAL TAKE-OFF AND MATER. DEMANDS ADMINISTR.
AUTOFIT CONCEPT GENERAL VIEW

Fig. A2

2.1 DIAGRAM

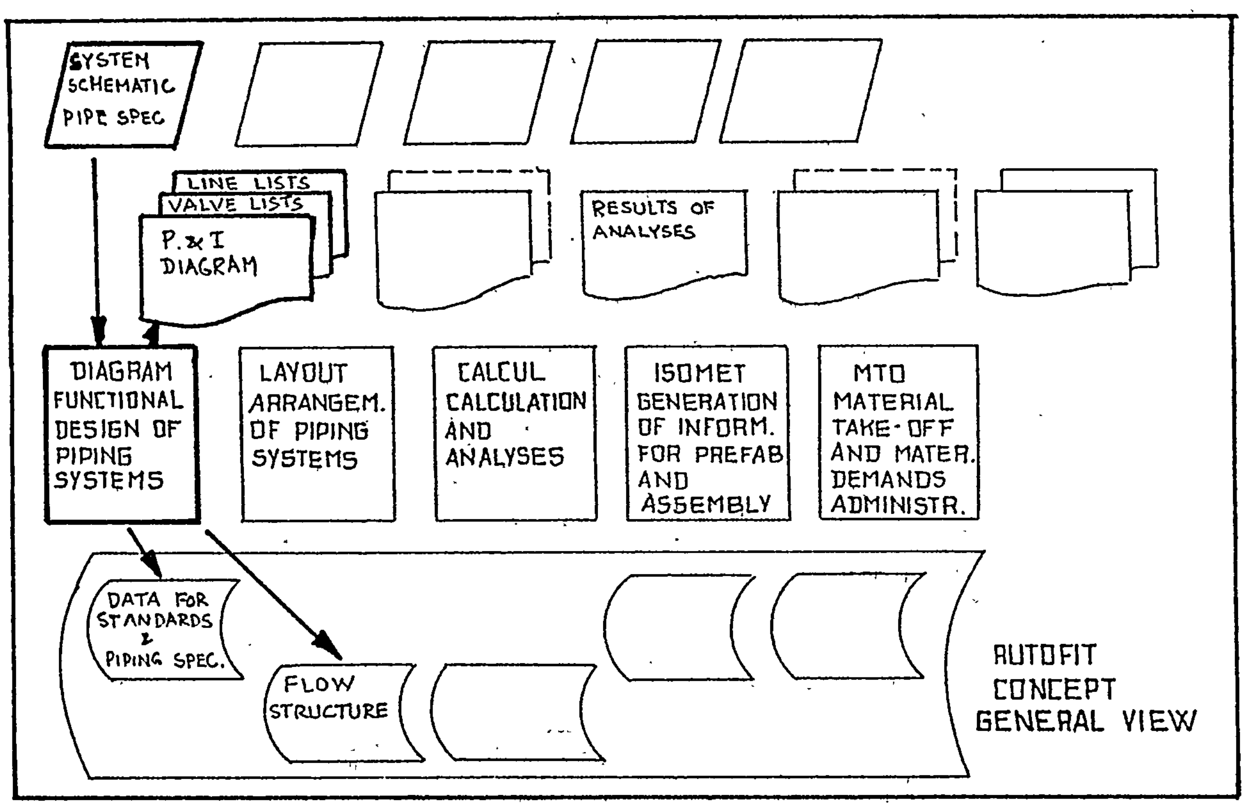
Covers the process up to and include complete P + I diagrams. Besides offering interactive drawing facilities, DIAGRAM is used to establish the flow-structure (topology) of the various piping systems and their instrumentation in the data base. Furthermore the database will contain pipe specification, standards and norms, component and instrument data. The DIAGRAM database provides input data to MTO for initial material summaries for purchasing and to LAYOUT for physical layout and routing and to CALCUL for various calculations.

The interactive schema drawing facilities are operational on NORD-10 x using Tektronix 4014/1. The screen menue is operated by the cross-hair. Drawings may be hard copied or directed to the plotter when final drawings are desired.

The remainder functions of DIAGRAM now under implementation are mostly interactive, but some intended for bulk input will use card reader as alterantive. However, totally, DIAGRAM will be operated on NORD-10. Since NORD-10 is used also as RJE terminal, card reader, line printer and paper tape punch are available.

DIAGRAM is scheduled for completion within 1979.

x Norwegian mini computer produced by Norsk Data, Oslo.



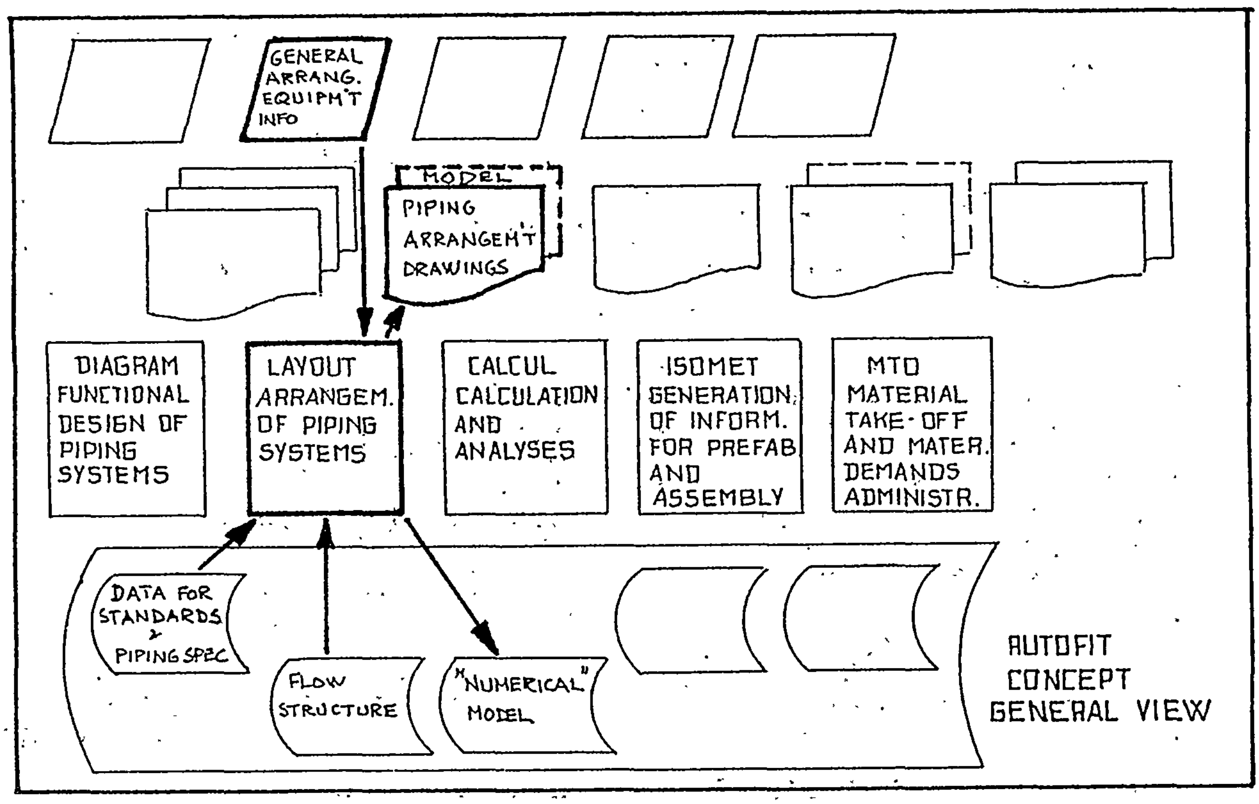
2.2 LAYOUT

Covers the continued process for providing complete piping systems arrangement with the corresponding numerical "model" in the data base. LAYOUT offers interactive facilities for definition of surroundings and constraints, volumes of components and restricted areas, for simple or automated routing and interference control and powerful facilities for vizualization and drawing. LAYOUT contains facilities for automatic selection of fittings according to standards and norms.

The LAYOUT database provides input to MTO for updated material summaries for purchasing, to ISOMET for generating work shop information and to CALCUL for various calculations.

This subsystem is specified and designed. An "experimental" version will be ready in August 1978, the purpose of which is to gain experience with interactive graphics in component and lay-out definition and simple routing.
A first version of LAYOUT is scheduled for completion first half of 1980, and an enhanced version with numerical interference control and automated routing primo 1981.

Since this subsystem is characterized by a very high degree of interactivity, it will be implemented on NORD-10. Tektronix 4014/1 will be used, but it is planned to use refresh screen as well.



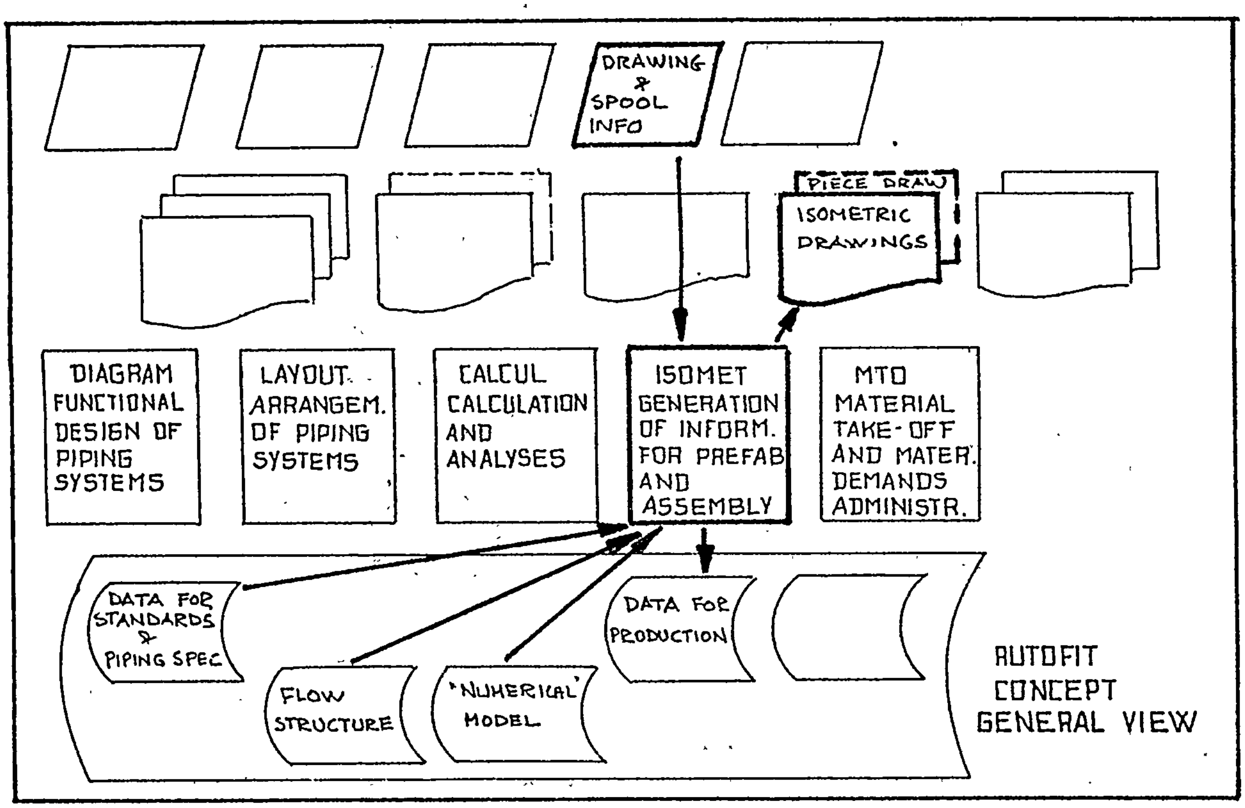
2.3 ISOMET

Covers the continued process of breaking down the arrangement in assemblies and pieces for prefabrication and automatic generation of the necessary drawings and other work shop informaton, including N/C bending tapes. If necessary, the drawings may be edited and manipulated interactively.

The ISOMET database provides input to MTO for final material summaries for purchasing. Since the ISOMET database contains full description of pipe elements, this information may be utilized also for various shop automation purposes.

The present version of this subsystem is a stand alone version operated partly on Univac, partly on NORD-10. By nature ISOMET is a typical "output" system with the purpose to convert, manipulate and present data base information in a rather repetitive and standarized way (isometrics, pipesketches, lists). The need for interactivity is less than in DIAGRAM and LAYOUT, and ISOMET is therefore characterized by a very high degree of automatic output. The ISOMET input programs are temporary and intended for bulk input lifted from a model or a conventional arrangment drawing. The input as well as the output programs providing automated output and therefore operated on Univac, while interactive editing of this output is performed locally on NORD-10.

When the databases from DIAGRAM and LAYOUT are available on NORD-10, the ISOMET subsystem will naturally be residing on the same computer.



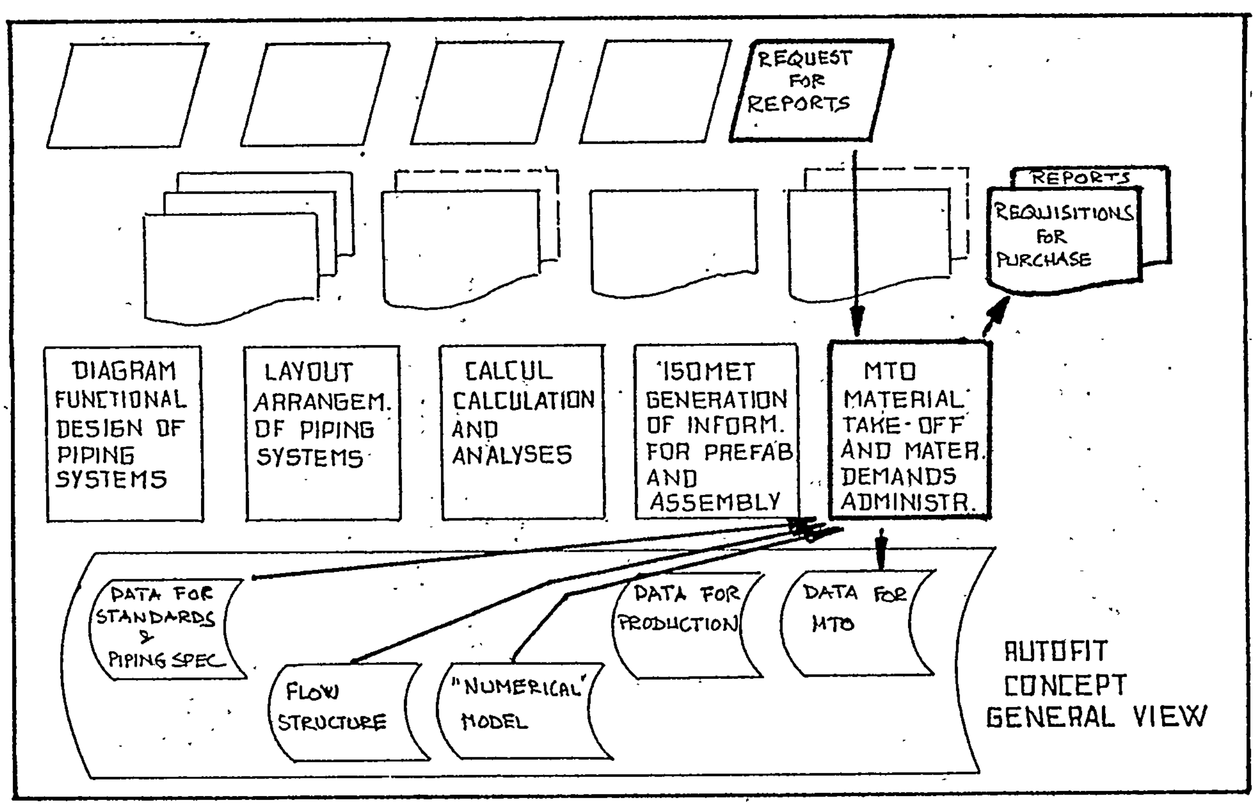
2.4 MTO

MTO extracts information from the "product" database and generate material demand summaries corresponding to the current engineering status. MTO provides material requisitions automatically and may also give material summaries sorted on different criterias such as: line no., area (block) no., group no., (for cost summary), activity no. (for planning), on materials code (for bulk ordering), contract type (for billing of extras), type of work (prefabrication or assembly), etc. MTO is command oriented and is presently operated in batch.

MTO provides information to the material administration system for order follow-up and warehousing. The purchase order no. is fed into MTO, which is capable of giving a complete status or requisitions and orders versus demands.

MTO is operational on Univac 1100 as a stand alone system with output as described, however, partly with provisional input programs, awaiting the availability fo the final product data base from DIAGRAM, LAYOUT and ISOMET. By then, MTO will become a typical output system.

The necessary links are designed and are scheduled for implementation concurrently with the completion of the previous subsystems. The intention is also to implement it on NORD-10 for operation in conversational mode.



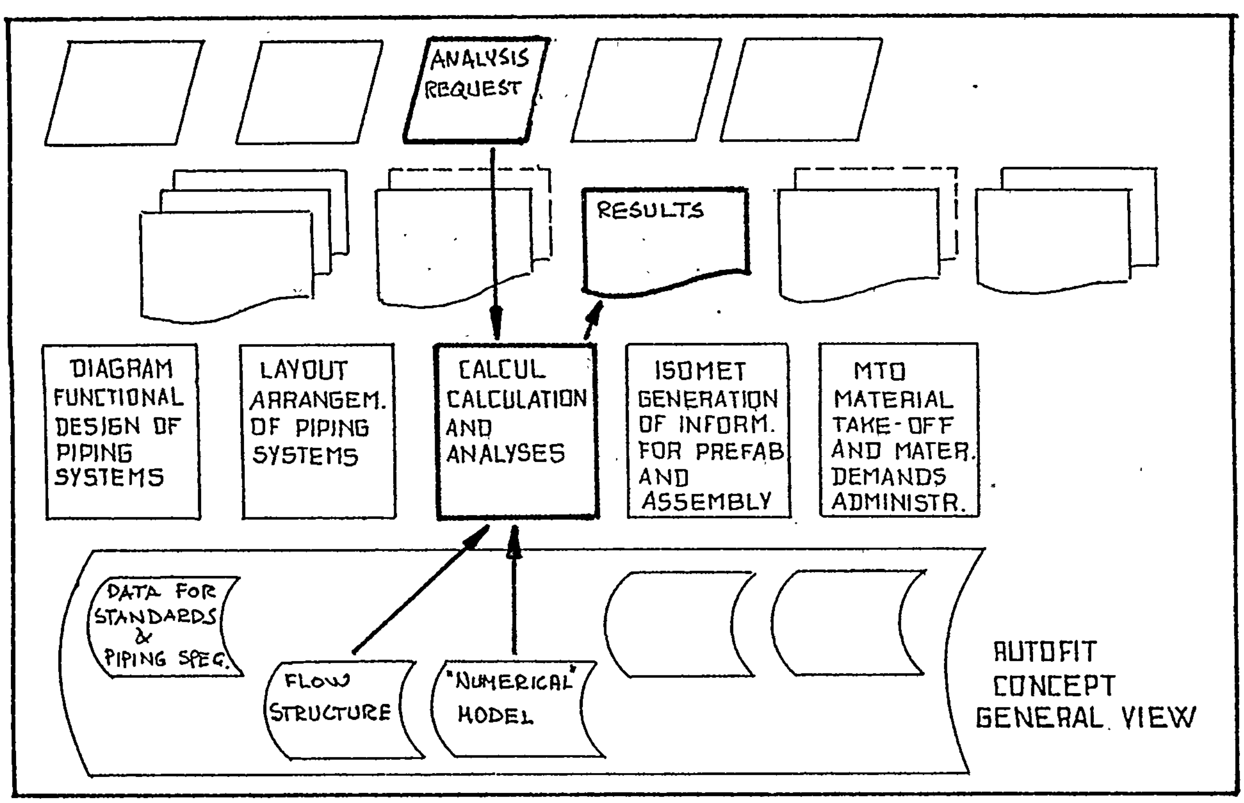
2.5 CALCUL

The flow-structure (topology) description and function data from the DIAGRAM data base and the 3-dimensional numerical model from the LAYOUT database serve as reference for various calculations which are performed in the respective phases. Such calculations may comprise mass balance, pressure drop, structural strength, analyses, etc. The extent and type of calculations will depend on type of piping system, industry, rules and regulations and other user dependent demands.

Therefore, CALCUL is more an opening to each user of AUTOFIT to rewrite present programs or develop his own new programs in interface with the AUTOFIT data base, rather than an off-the-shelf library provided as standard AUTOFIT routines.

Calculation and analysis programs are usually batch or in some cases operated in dialogue mode. Possibly except for structural calculations by advanced FEM systems available on large main frame, it is assumed that most calculation programs may be accommodated on the same computer as AUTOFIT.

There are no specific plans to develop calculation programs as off the shelf packages as part of AUTOFIT.



3. HARDWARE

Great efforts are made to develop AUTOFIT as a portable and self-contained software with the highest possible degree of hardware independence.

Nevertheless, certain hardware have been selected during development, mostly because of availability and partly because of choice for several concurrent developments.

The hardware being used comprise general purpose equipment such as:

- o Univac 1110 as central main frame.
- o Nord-10 as local machine for interactive graphics, for RJE terminal connection to Univac and for plotter control.
- o Tektronix 4014/1 with EGM option, tablet and hard copy unit.

The operational mode of the various subsystems are already described. However, it does not necessarily represent the final solution when AUTOFIT is completed.

Since AUTOFIT is basically portable, the user is given a certain amount of freedom to pick hardware such as computer, screen and plotter.

As appearant today, a minimum computer requirement for accommodation of AUTOFIT will be 192 K words, 2 discs drives, 1 tape station, card reader, line printer, paper tape punch. The final configuration in terms of capacity cannot be specified in detail now, simply because the system is not yet completed.

Other capacity demands such as number of work stations (screens) are set by the user environment: volume of work to be performed, the geographical distribution of work and whether the same hardware and work stations are intended also for other applications. The core requirements on Nord-10 will increase with the number of work stations in a multi user mode operation.

It is technically feasible to operate AUTOFIT on Univac 1100. The efficiency is, however, entirely dependant on the computer center operation policy and work load.

PRESENT SIAG-DEVELOPMENTS

PART 4

Hardware Considerations in the

AUTOKON/AUTOFIT projects

Introduction

This part of the AUTOKON/AUTOFIT will deal with the following aspects

- o Trends in Hardware development
- o AUTOKON/AUTOFIT hardware considerations
- o Graphics hardware development
- o How does the "turnkey" systems fit into the total AUTOKON/AUTOFIT system
- o SRS - SIAG development policies

1. What types of systems are AUTOKON and AUTOFIT ?

Let us review two important points

a Information Systems

This means: They are to be considered a central information source from which the different application programs (which belongs to AUTOKON/AUTOFIT) fetches and stores data.

b Topological product model

The key to this information is a product model which is a logical description of how the different parts and prices of the product are tied together.

To administer this information consisting of topology and geometry requires a powerful and resource demanding Database system. The storage requirements are also great.

In addition several applications, with several users each, may wish to access this informations simultaneously.

Finally most of the applications wish to utilize interactive Computer graphics as a means of communication between the user and the information system.

In order to evaluate the possible hardware configurations for these resource demanding systems it is necessary to take a look at hardware development trends in general.

2. Hardware trends

The hardware development trends for todays MINI/MIDI computer can be explained by the following points

- o The introduction of LSI (Large Scale Integration) technology is bringing the price and size down on basic components. (CPU's, memory etc.)

- o Due to this fact there is a tendency to move in the direction of 32 bit hardware (instead of 16 bit).

- o MICRO computers will be used as logical components for functions such as

  - driwing plotters and digitizers
  - interfaces towards equipment
  - etc., etc.

- o MULTI - CPU architectures where a particular CPU may be assigned one particular function or task

  ex.
  - Database function
  - display handling

- o Distributed processing utilizing several computers connected together. This has a positive influence on the following factors

  - Expandability
  - Total system downtime
  - Graphics devices may be connected through short high speed lines
  - etc.

Example of the last two points are shown on fig. 1 and 2.

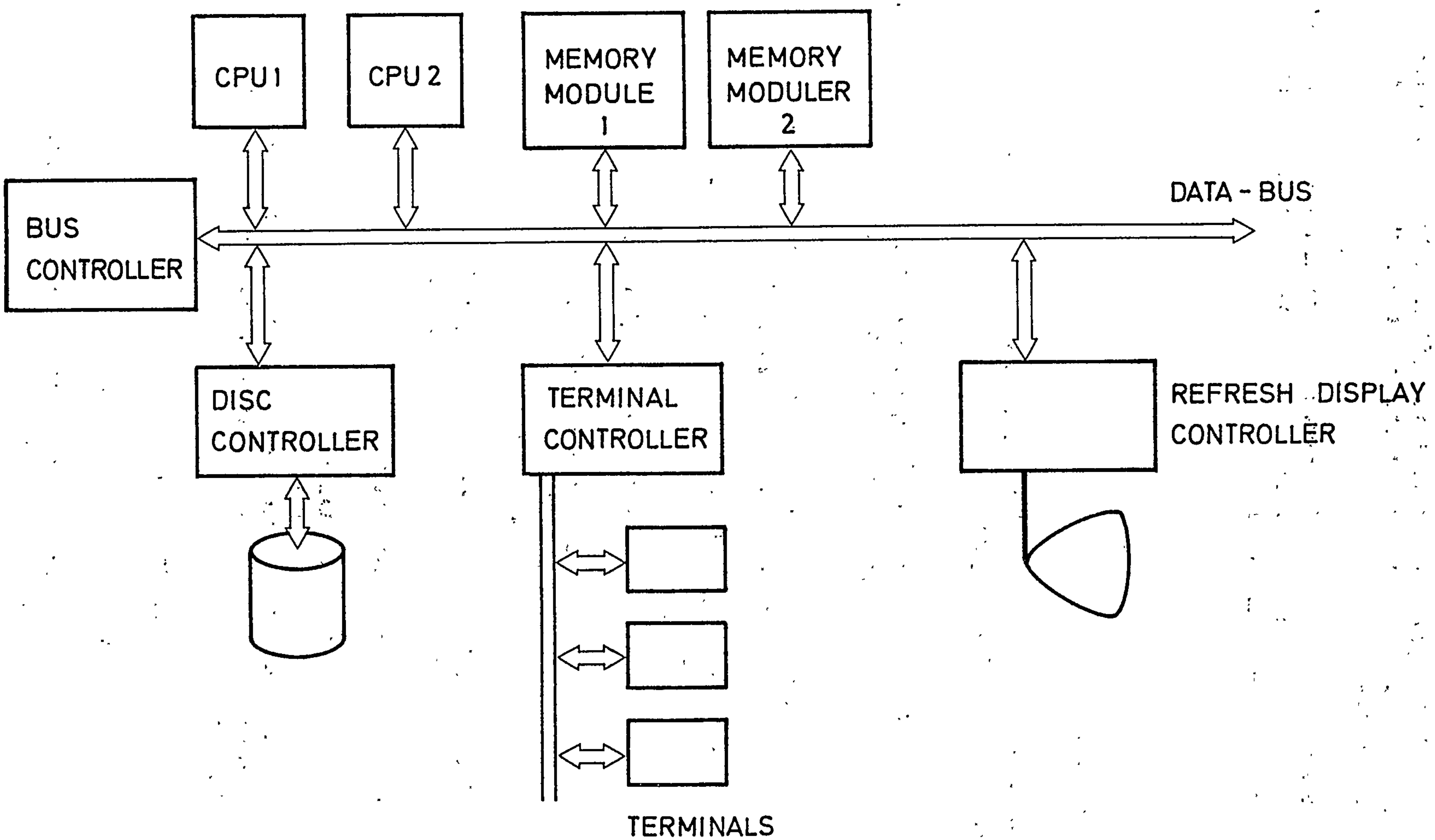


Fig.1 MINI COMPUTER HARDWARE ARCHITECTURE

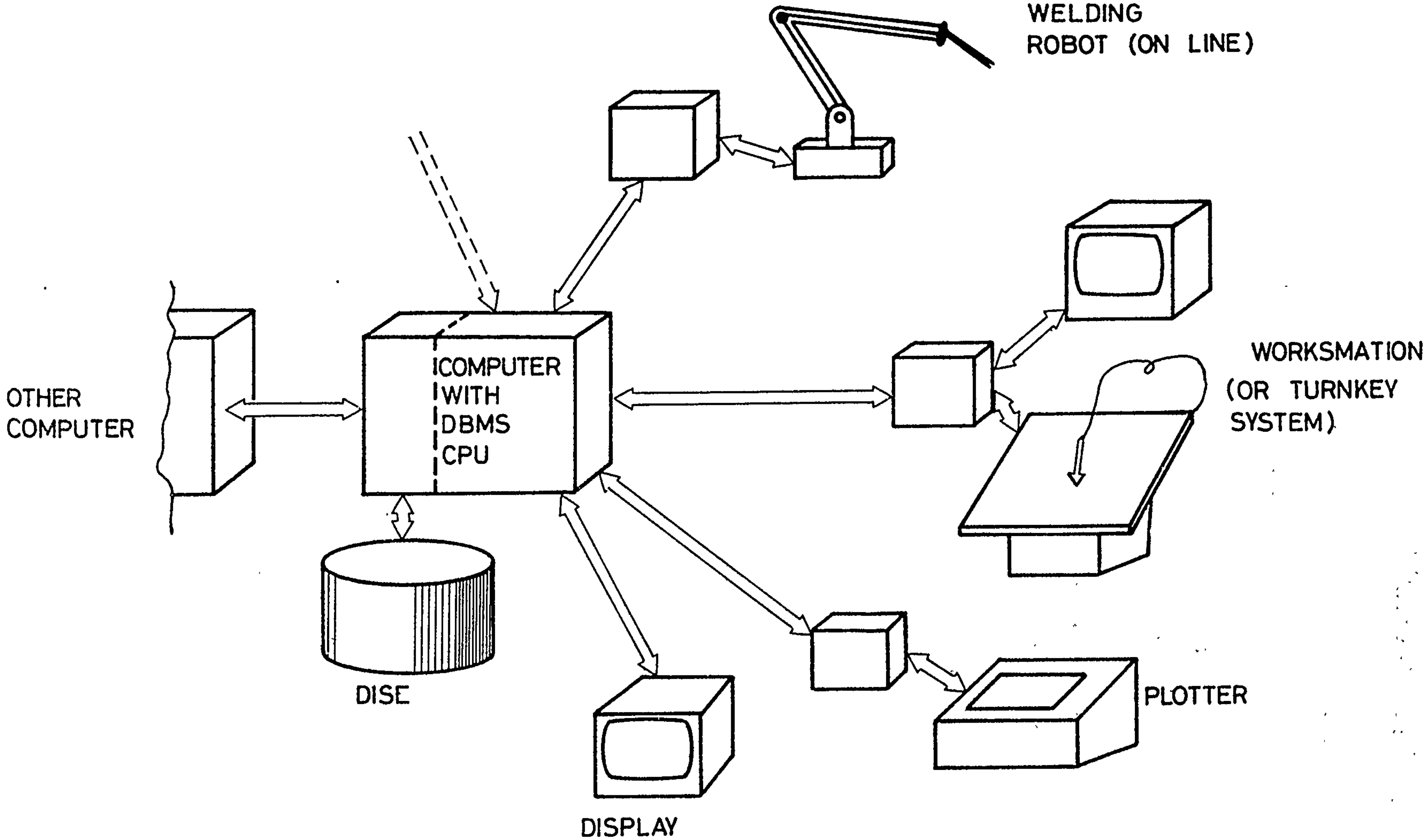
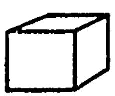


Fig.2 FUTURE "MINI" CONFIGURATION


microcomputers or intellegent controllers

3. AUTOKON/AUTOFIT estimated performance

We have tried to estimate resource demands based on equipment we already know.
The machine configuration for the estimate is a NORD 10/S 16 bit mini computer with

- o 192 - 256 K 16 bit word memory
- o 5 - 6 terminals (of these 3 tektronix 4014)
- o Mass storage 66 - 100 Megabytes
- o Magnetic tape station
- o On line plotter

The following performance was "estimated".

LOAD:

3 - 5 users simultaneously

- on same or different sub-systems
- on same or different database
- sporadic communication with systems on other machines

RESPONSE TIMES:

- Graphical interaction 2 - 5 sec.
- Updating database 1 ÷ 30 sec.
- switching application 1 - 5 min
- changing (redefining) product model 1 - 6 hours

It should be noted that data given for storing on the database covers aspects from storing of simple geometry to complex topological structures.

4. Graphics Hardware development

Just like for the MINI computer the LSI technology will make a huge impact on the Graphics hardware

A typical Graphics System will contain one or more microcomputers performing different functions such as

- Picture processor for Refresh System. This indicates that refresh systems will be more attractive(maybe in connection with storage capabilities)

- Communication processor to host computer

- Basic Graphics functions such as

  - 2D/3D transformations
  - Window/viewporting
  - "Hidden line" removed

On the whole this indicates cheap workstations capable of acting as stand alone systems for certain input/output function, f. inst. digitizing, drawing editing etc. in much the same way as the Turnkey systems of today only at a much lower price.

However, we see these work stations only as graphic input/output devices for the total information system capable of doing some stand alone functions, <u>not</u> as a medium for implementing the total system.

This would only serve to concentrate the processing problems as the work station instead of distributing the processing between the workstation and the total information system.

5. How do we prepare for known and unknown turnkey systems ?

The introduction of graphical turnkey systems or work stations allows us to reduce the processing load on the host computer(s).

However, they do introduce the problem of defining "software intersection" between the host computer(s) and the workstation since no two turnkey systems look alike

- o they supply different functions

- o they represent data differently (f.inst. geometry)

In order to reduce the amount of work involved in integrating a turnkey system the following aspects have been given attention

- o To separate the Topology and Geometry description of the product. While many turnkey systems handle geometry adequately they do now handle your particular products topology

- o To separate functions that

  - manipulate topology
  - manipulate geometry

- o To separate functions that manipulates graphics data

  - Display code generation
  - Display code manipulation
  - 2D & 3D transformation
  - etc.

- o To base the development on identical software packages or building blocks to reduce overal maintenance and adjustment to new turnkey systems

  - Database/file systems
  - Command processor
  - Graphics software
  - Geometry routines
  - Text manipulations
  - Documentations
  - etc.

6. Development policy

We would like to finish by summing up our development policies

- PORTABILITY

  We do want to make portable systems. This means independance of hardware, both computer and turnkey/workstation, although this does not allow us to optimize on a given configuration initially. It allows us to adjust to new hardware that comes along (or hardware already in a yard).

- SOFTWARE STANDARDIZATION

  We are attempting to base our development on common software packages.

- We develop for 16 bit minis with an address space of 64 words although we believe that the 32 bit machines will dominate in the future.

- We believe in MINIS (or MIDIS) for interactive work either connected to other MINIS (MIDIS) or to main frames.

- We do develop using Tektronix 4014 but try to accomodate the cheap, intelligent work stations that we believe are comming.

DETAIL ENGINEERING MODULE (DEMO) AND OTHER SPADES DEVELOPMENTS

Albrecht Schulze
Cali and Associates
Metairie, Louisiana

Mr. Schulze is Director of Systems Developments at Cali and Associates. In this capacity, he is in charge of new developments for the SPADES system. He has 12 years of experience in developing computer systems for shipbuilding applications. He has a M.S. degree in naval architecture from Technical University in Hannover, Germany.

DETAIL ENGINEERING MODULE

When we planned the Detail Engineering Module some time ago, we had set three objectives to be achieved:

1. The verification of the data base loading by means of drawings which can be extracted with a few commands.
2. The development of a powerful program oriented towards engineering needs, which could be utilized in generation of the detail drawings.
3. Expanded data base loading and recalling capabilities for the entire 'SPADES' System beyond the mere wire model, to include details of holes, stiffeners, seams, brackets and internal contours.

Today, I am able to report that the first two objectives have been accomplished. In fact, the Detail Engineering Module is being used already in a production environment at a major shipyard.

In order to show you how the Detail Engineering Module can be utilized, I have worked out a little demonstration with one of the lofting contracts our Company is performing at the present time. The vessel is a Patrol Gunboat of the PGG 511 class, which measures 190 feet in length, and about 26 feet in beam. The lines of the boat have been computer faired

by the 'SPADES' Fairing Module, and loading of the data base has been performed with the HULLOAD Module for the purpose of lofting.

Partially to check out the hulloading job, and partially to find out how much the Detail Engineering Module could produce, I called out a series of side frames with this input deck (Fig. 1). The result is a drawing (like Figs. 2, 3 and 4) for each of the frames. Each of the drawings has its unique identification number, composed of the ship number, program number (DEMO), the input deck number, and a modifier within the input deck and the actual frame number.

The actual detail drawings of this contract show this series of side frames drawn on top of each other, which prompted me to do the same thing with Fig. 5 as a result. This picture looks somewhat confusing at first. But it reveals the value of the program as a data base checking tool. It would be immediately visible if a longitudinal has the wrong location, orientation or size. In fact, we were puzzled by the irregular pattern of the Tee's on the first platform. Another new development of the 'SPADES' System, the Shipfile Verification Report, helped immediately to clear up the mystery. This report lists all longitudinals by characteristics (Fig. 6), and longitudinals L10 and L9 are shown sloping outboard in the frame range in question.

Next, I tried 'DEMO' for three web frames, 26.1, 31 and 35 (Figs. 7 through 10), and Bulkhead 22 (Figs. 11 & 12). The Bulkhead shows an

optional grid that may be called out for the purpose of orientation and reference in detailing.

Now, I would like to show you how 'DEMO' could be used for detailing. Again, I started out by simply calling three webframes, 7, 12 and 17, from the data base (Figs. 13 through 16). It is apparent that Frame 7 is somewhat different from Frames 12 and 17 because of the breast-hooks that land against it in the lower portion. But the webs are still similar, and coding can be identical for all three frames. In the Deck No. 2 (Fig. 17), the internal contours of side web and deck web are coded. I have added some writing through the drafting machine and then terminated Frame 7. The result is Fig. 18. Following the 'LOAD' card for Frame 7 is some coding to complete the detailing of Frames 12 and 17. Some minor calculations precede the definition of four holes, and other calculations are followed by the definition of the five horizontal stiffeners. Figs. 19 and 20 show the results for Frames 12 and 17.

Input Deck 4 (Fig. 21) is a slight modification of Input Deck 2. The Command 'LIMT' has been added in order to cut the drawings just above the Platform. Figs. 22, 23 and 24 show the result. This could be useful if the lower portion of the Web is needed to be drawn at a larger scale for detailing.

Finally, the contract drawings showed two details. One is the cut-out at the shell knuckle in a very large scale. Input Deck 3 (Fig. 25) shows the

coding necessary for that detail (Fig. 26). The other detail is the connection of the deck and side webs. Input Deck 5 (Fig. 27) was generated by a copy from Deck 2, deletion of unnecessary coding like the holes and stiffeners, and addition of the 'LIMT' Command. Fig. 28 shows detail 5B.

The drawings that are generated by 'DEMO' at the shipyard enjoy great popularity and are hard to come by. I was able to get hold of a few, which I would like to show you as samples of application.

Fig. 29: Two partial webframes of a Navy Tanker

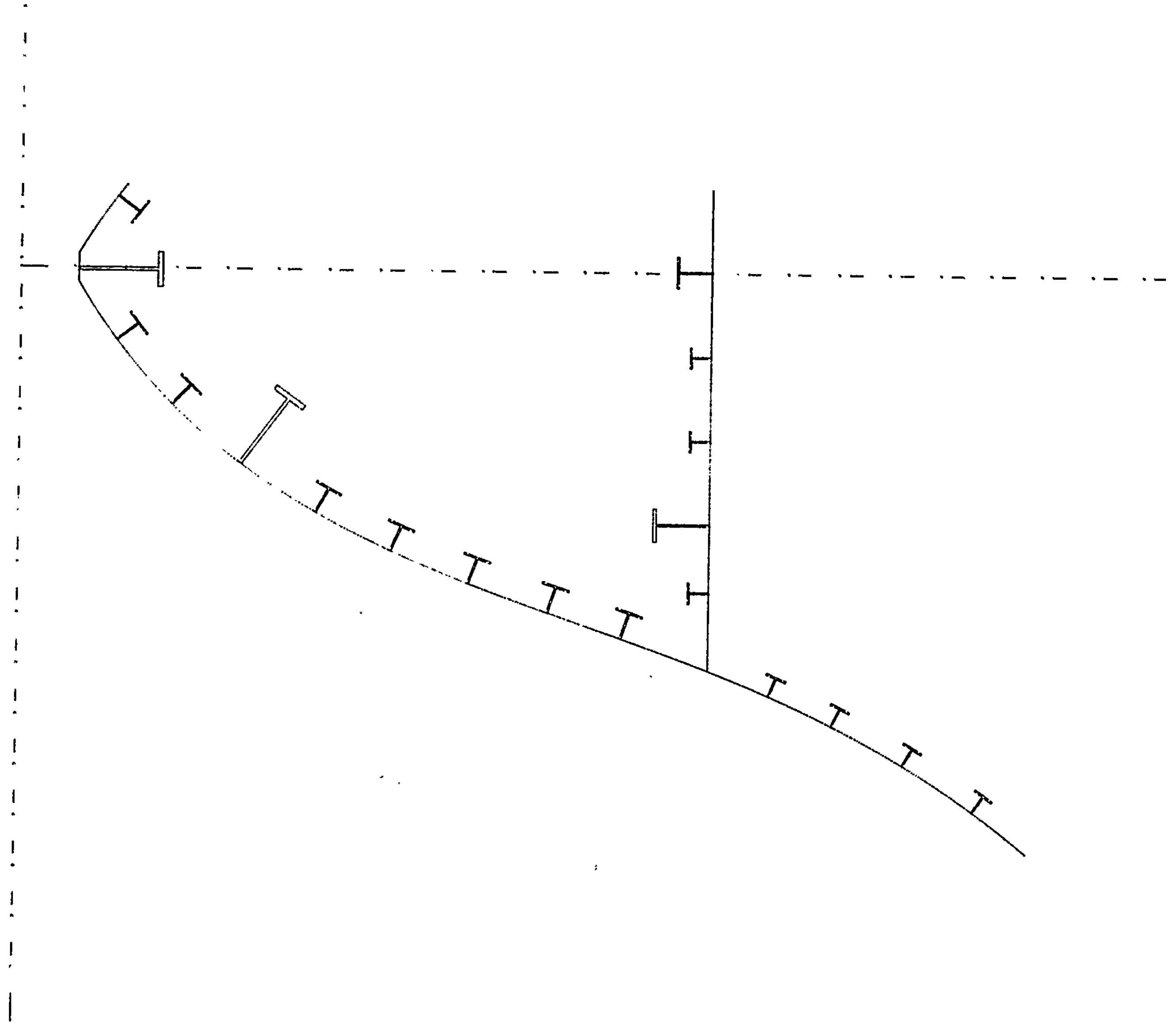
Fig. 30: Partial stern frame of a Container Ship

Fig. 31: Midship section of a Tank Barge.

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

INPUT UPDATING          DATE  06/12/78     TIME  01/09/37      RUN NO.   4
JOB PB01  PROG. DEMO                 INPUT 0010    REV. NO.   4        PAGE   1

INPS                  N      10                                     7300100008
LIMT                                        X    12    Y    1       7300100012
DRWG TRSV        FWD   F 231     F 251     F 271     F 291          7300100016
                       F 321     F 341     F 381                    7300100020
RMKS SIDE FRMS. STBD LKG FWD PORT SIM & OPP                         7300100028
STRT                    -4        -10                               7300100032
LOAD                   F 231     F 381                              7300100036
                                                                    7300100040M
                                                                    7300100044M
                                                                    7300100048M
                                                                    7300100052M
                                                                    7300100056M
                                                                    7300100060M
INPE                                                                7300109999
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

               SEVERITY = 0    INPUT IS STORED WITH REV. =   5

                                 INPUT IS EXECUTABLE
```

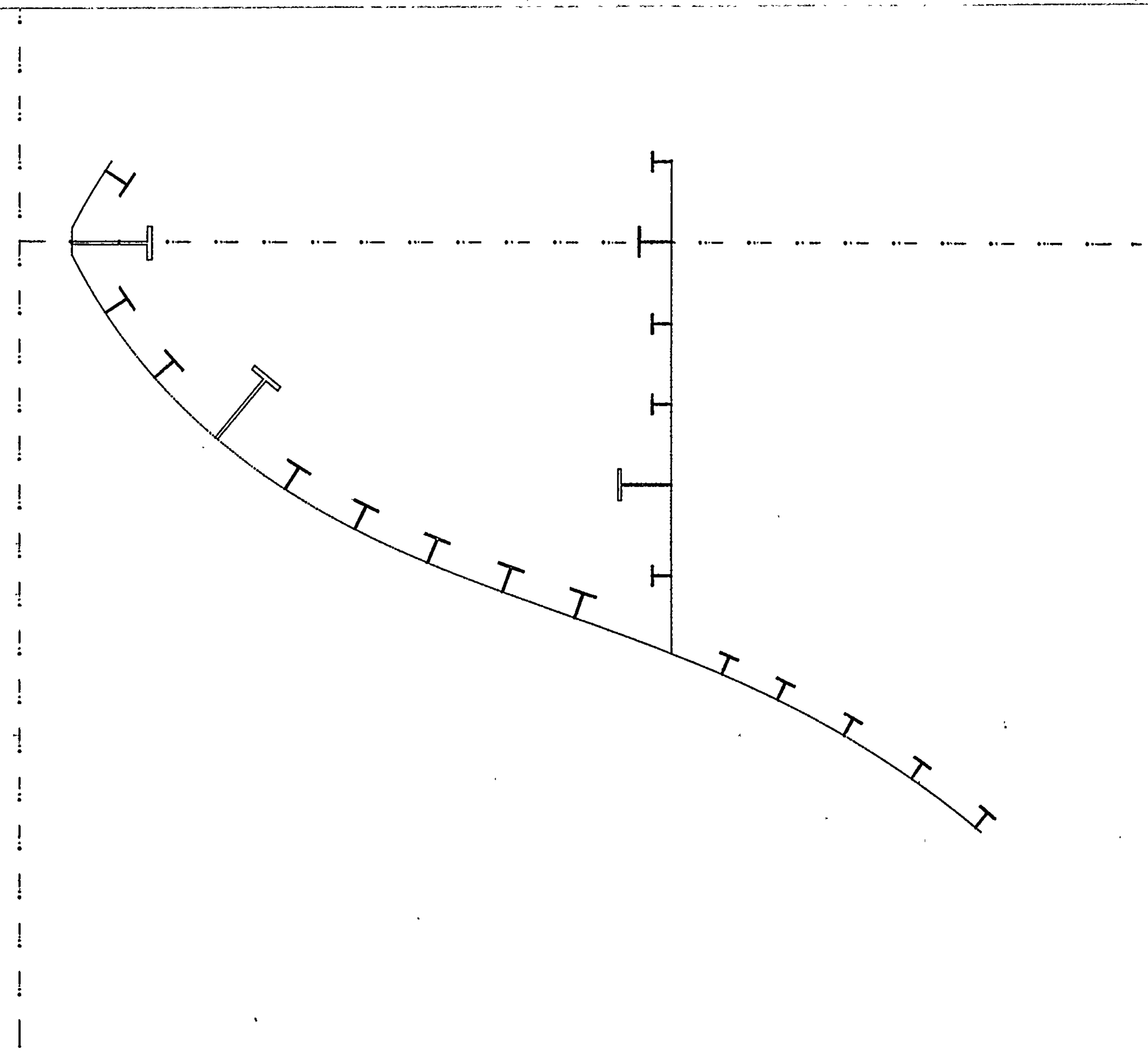
Fig. 1

Fig. 2



TAPE NO. 730010 - 2 F 23100

Fig. 3



TAPE NO. 731010 - 2 F 25100

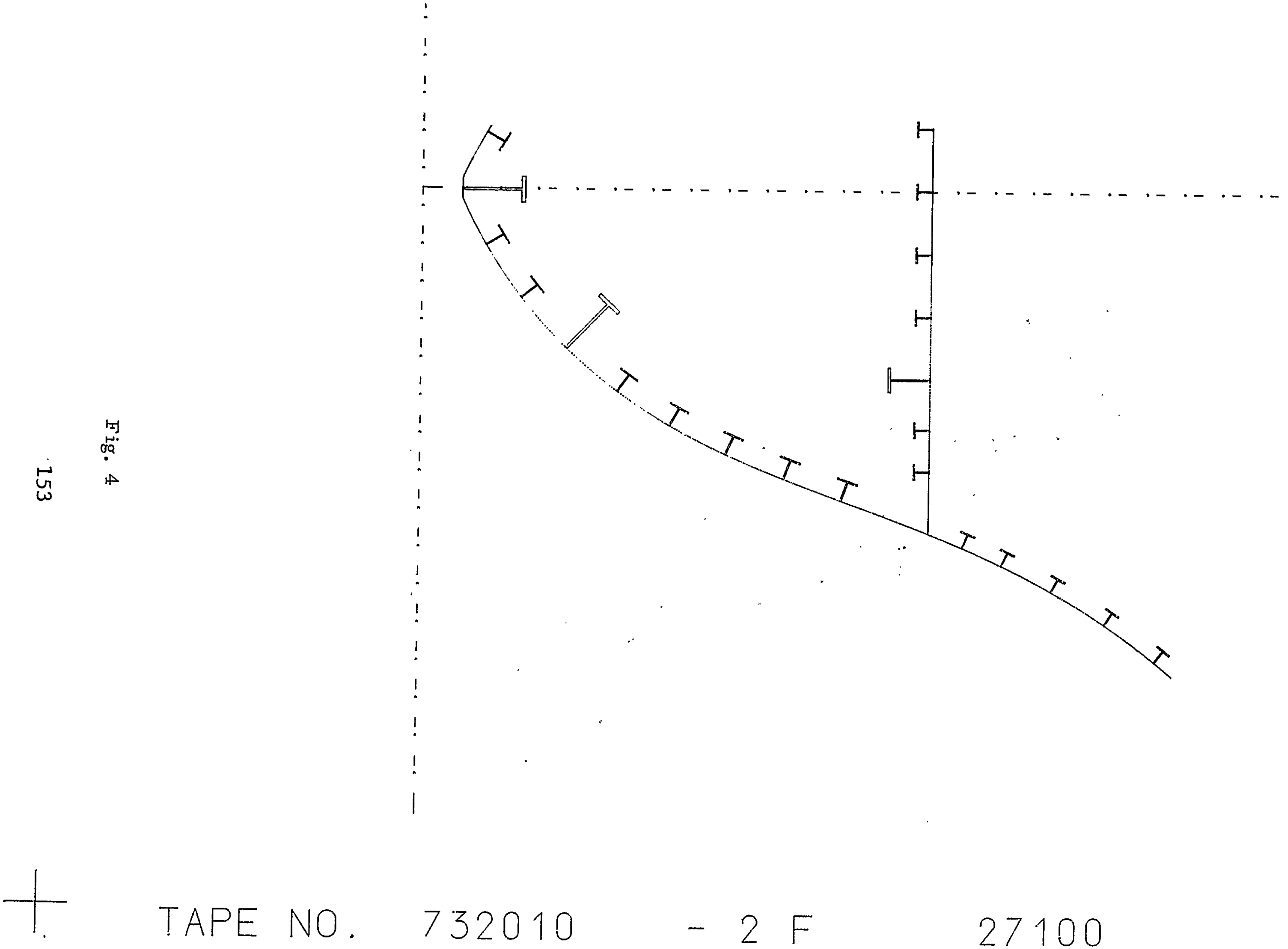
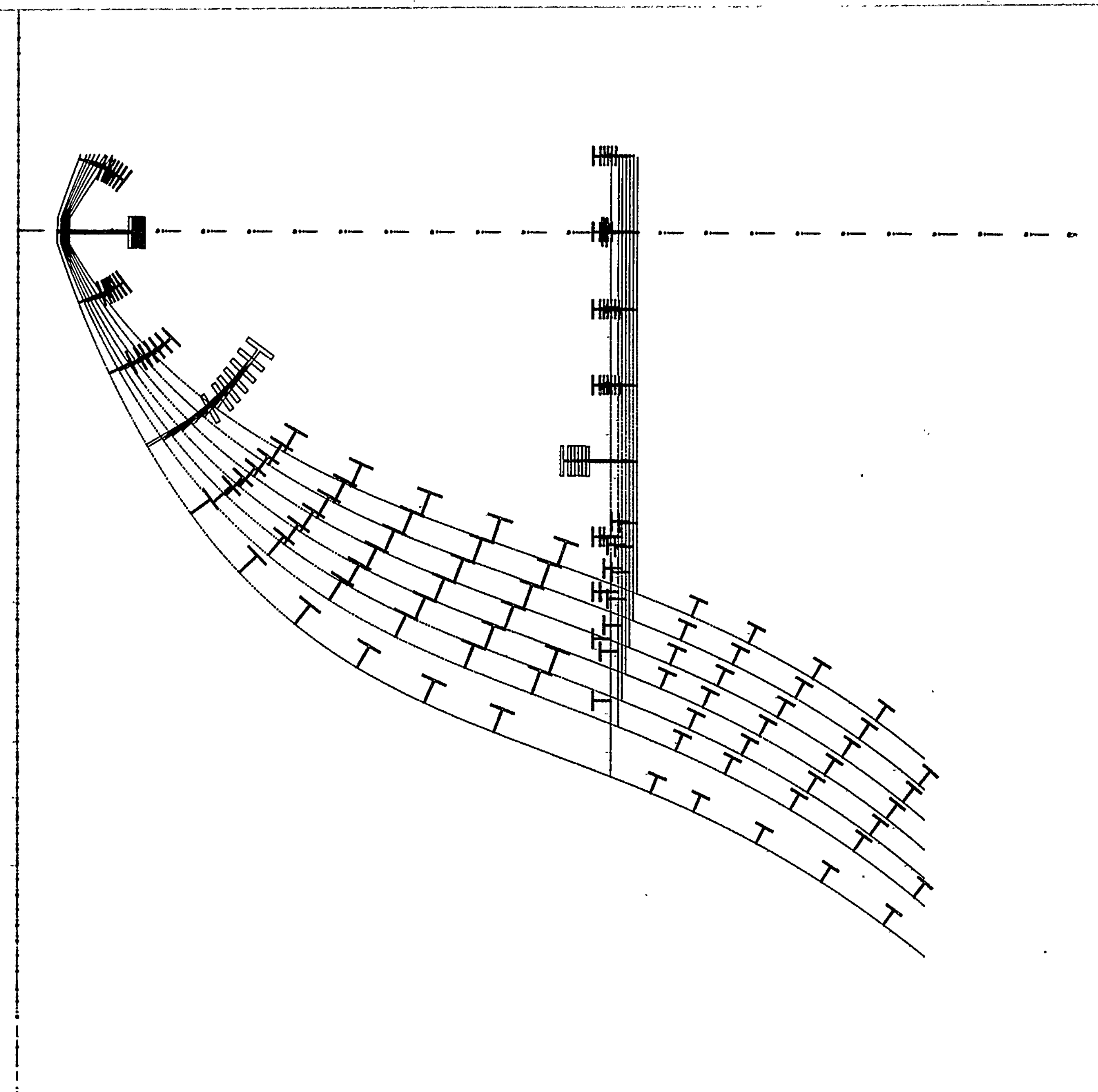


Fig. 4



TAPE NO. 1736010 - 2 F 38100

Fig. 5

S L10	4100	TO	7000	SLPE	Y	0.487	1.003	K	100	903	NORM	180.000
	8100	TO	9100	SLPE	Y	1.249	1.495	K	100	903	NORM	180.000
	10100	TO	12000	SLPE	Y	1.726	1.958	K	100	903	NORM	180.000
	13100	TO	17000	SLPE	Y	2.175	2.825	K	100	903	NORM	180.000
	18100	TO	22000	SLPE	Y	3.031	3.651	K	100	903	NORM	180.000
	23100	TO	26100	SLPE	Y	3.811	4.291	K	100	903	NORM	180.000
	27100	TO	31000	SLPE	Y	4.467	4.996	K	100	903	NORM	180.000
	32100	TO	35100	SLPE	Y	5.166	5.676	K	100	903	NORM	180.000
	36100	TO	38100	SLPE	Y	5.835	6.154		100	903	NORM	180.000
	40000	TO	40000	LINE	Y	6.314	6.314		-101	903	NORM	180.000
	41050	TO	43100	SLPE	Y	6.526	6.774	K	100	903	NORM	180.000
	46000	TO	47000	SLPE	Y	7.157	7.269	K	100	903	NORM	180.000

Fig. 6

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

INPUT UPDATING          DATE  05/31/78    TIME  23/16/40     RUN NO.    3
JOB PB01  PROG. DEMO                  INPUT 0011    REV. NO.   2          PAGE   1

INPS                 N       11                                       7300110008
LIMT                                                 Y    2           7300110012
DRWG TRSV        FWD    F 261      F 31       F 351                   7300110016
RMKS WEB FRMS                                                         7300110020
STRT                     -3        -13                                7300110024
WRIT3                    -2 3          0     A -90           3        7300110028R
WRIT3WEB FRAME       STBD LOKG FWD PORT SIM & OPP               *     7300110032R
                                                                      7300110036D
LOAD                    F 261      F 351                              7300110040
INPE                                                                  7300119999
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

              SEVERITY = 0    INPUT IS STORED WITH REV. =   3

                                 INPUT IS EXECUTABLE
```

Fig. 7

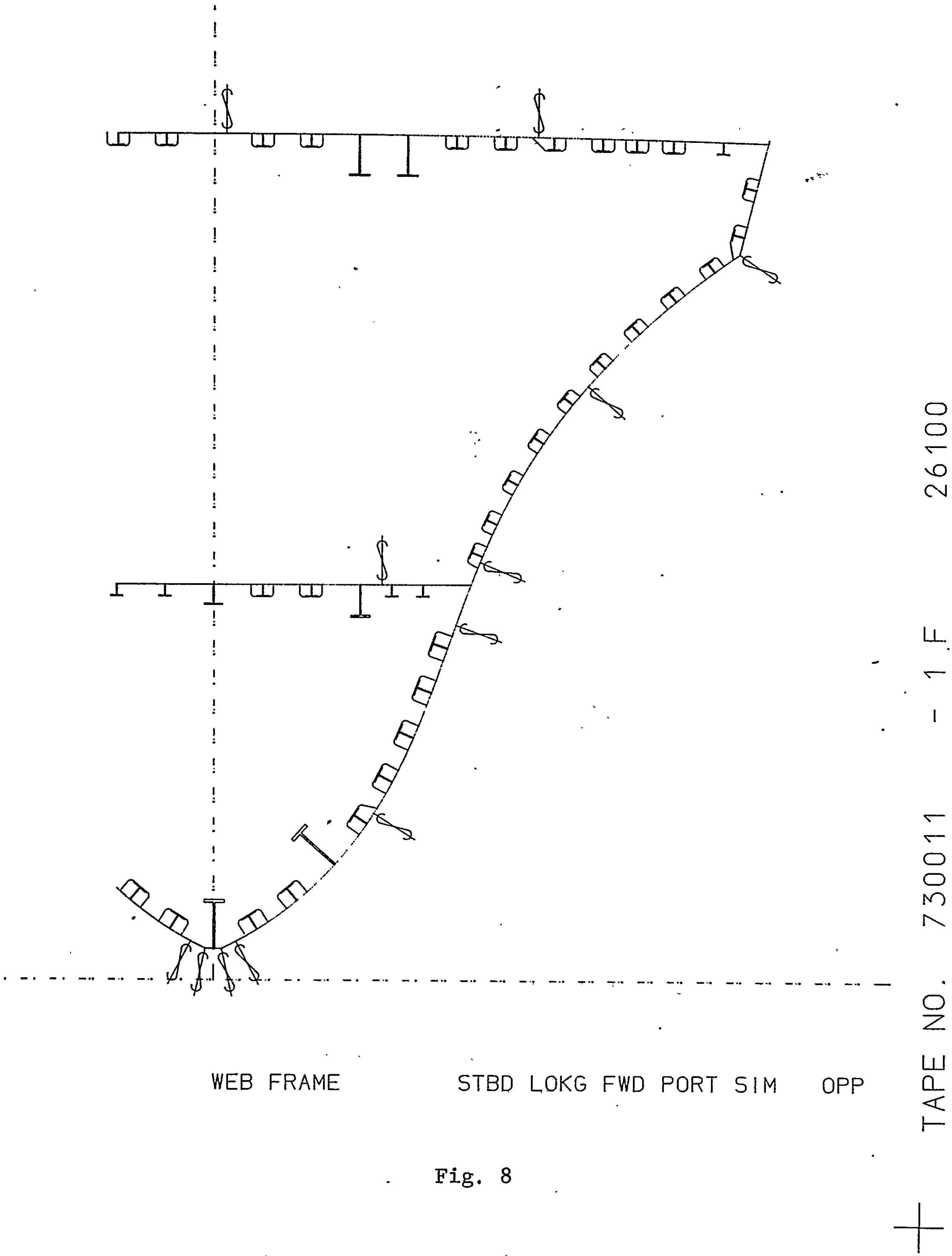


Fig. 8

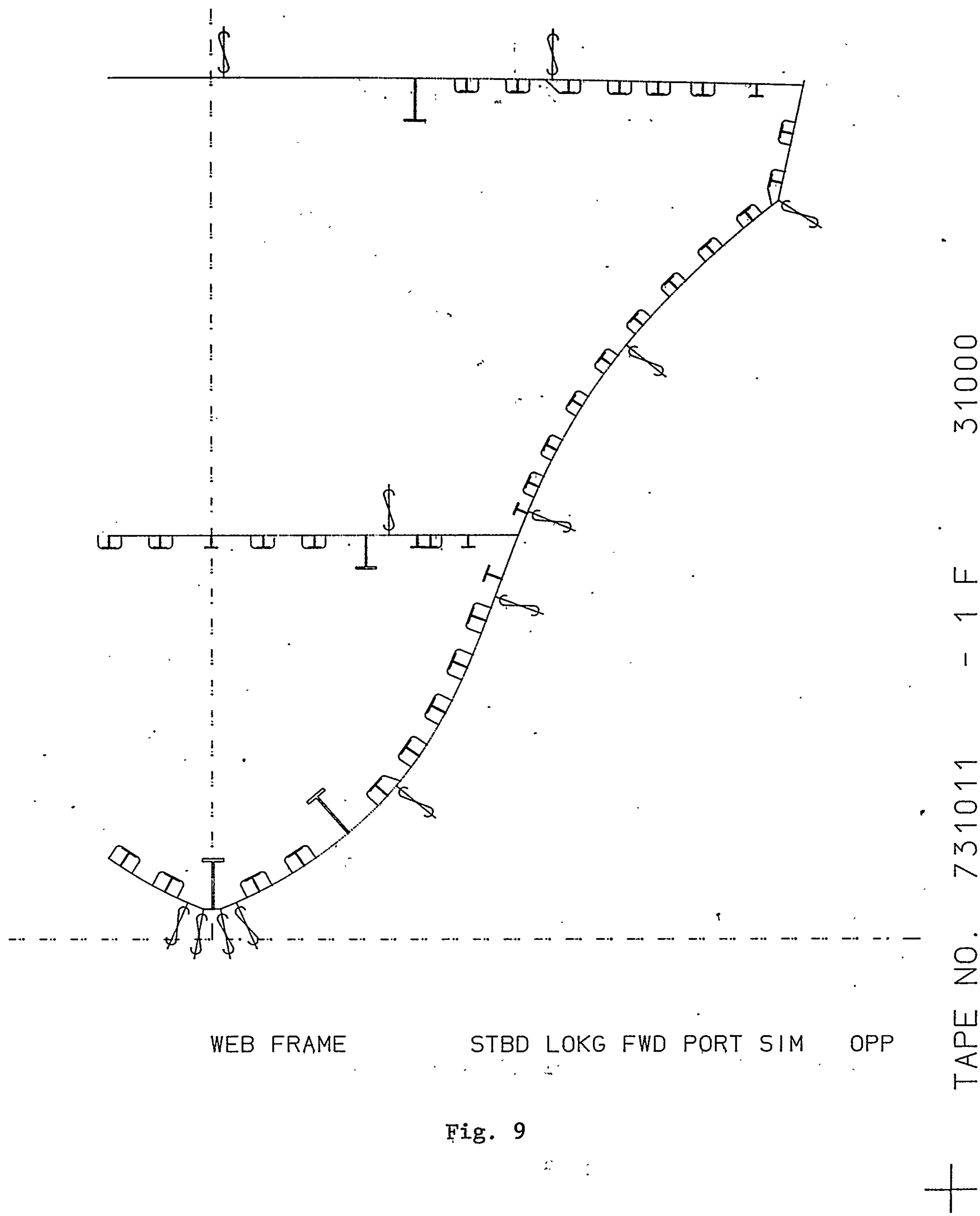


Fig. 9

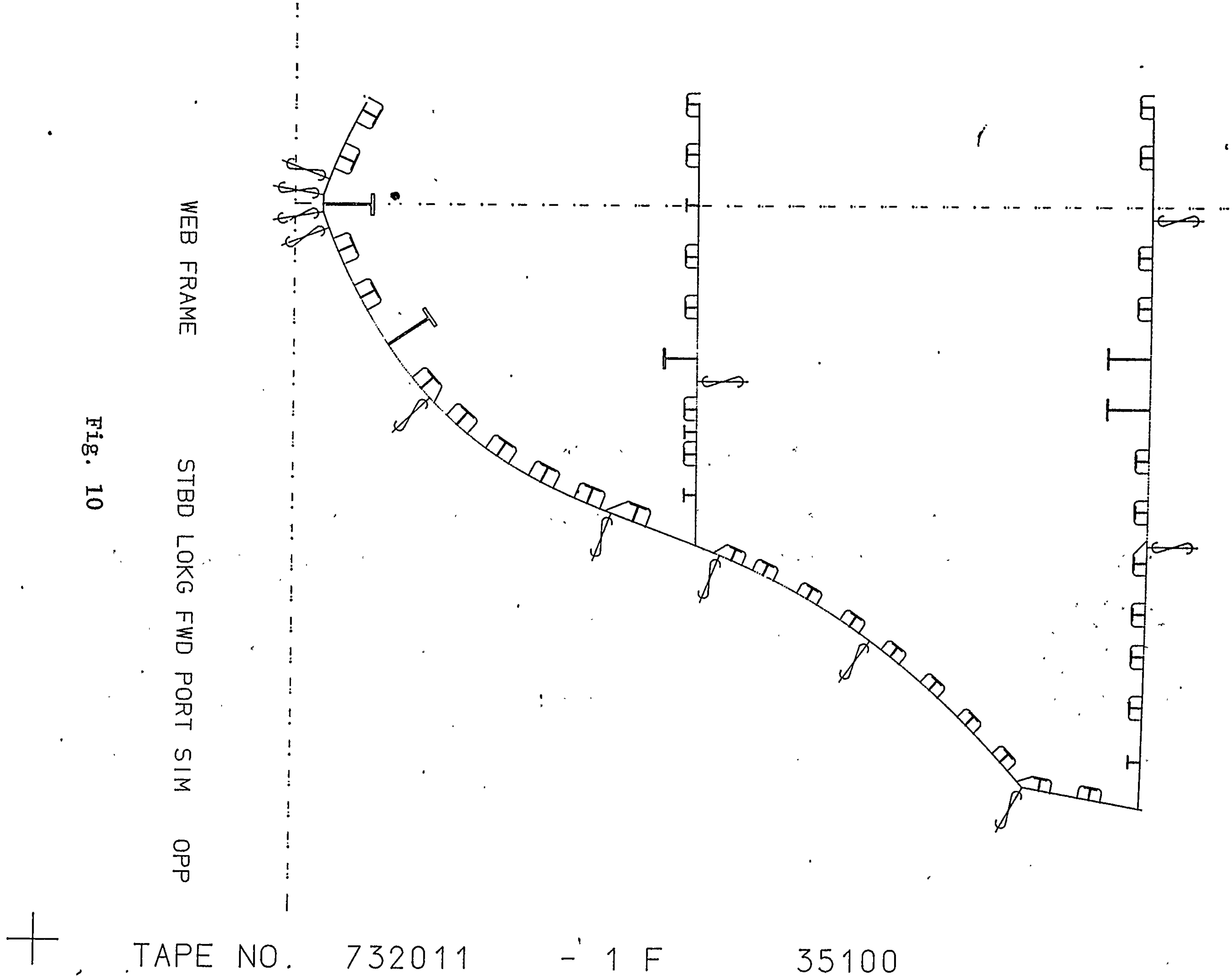
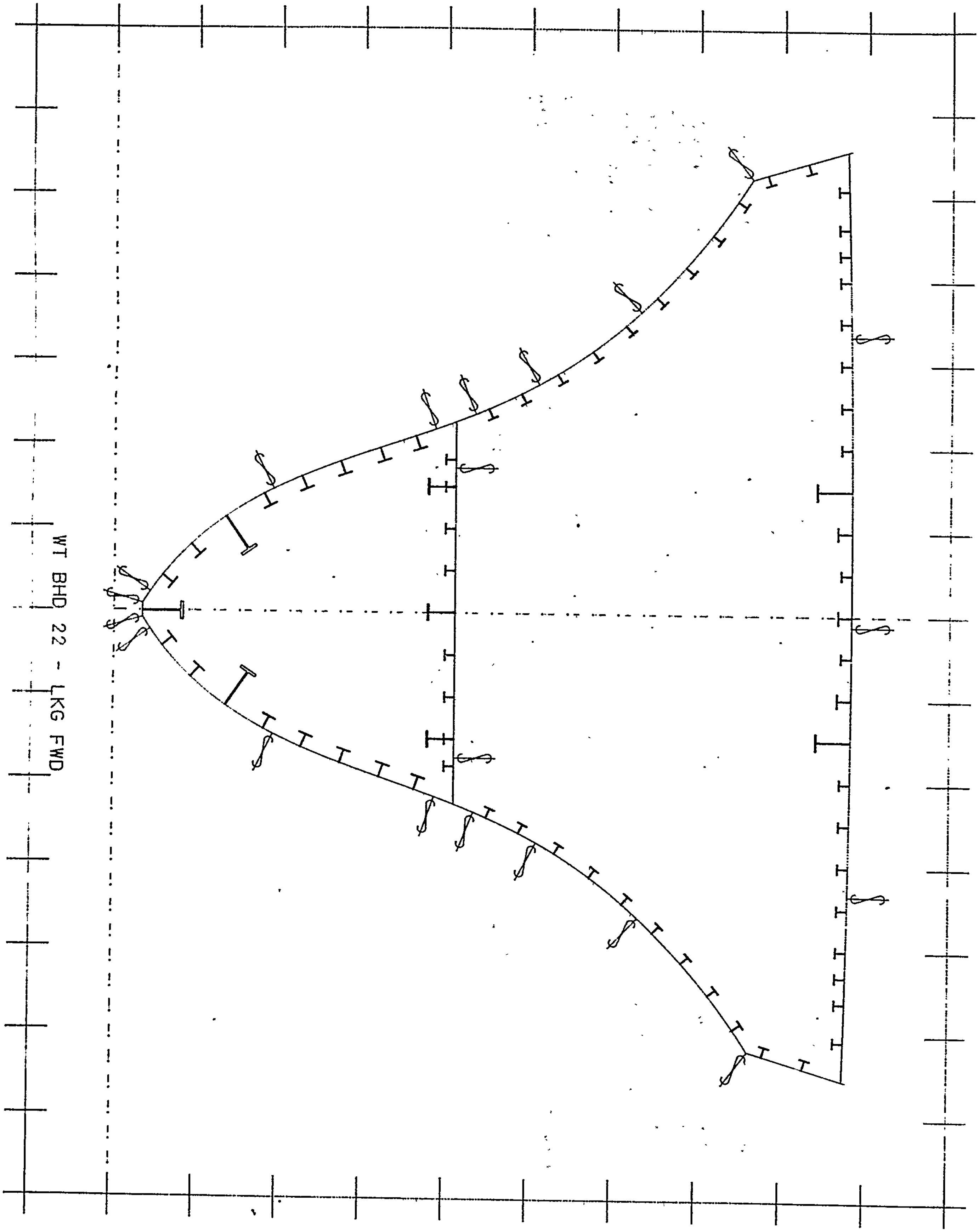


Fig. 10

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

INPUT RELOAD'G          DATE  05/31/78     TIME  23/17/58      RUN NO.    2
JOB PB01  PROG. DEMO              INPUT 0012    REV. NO.   1         PAGE   1

INPS                  N      12                                      7300120012
DRWG TRSV         FWD   F 22                                         7300120016
RMKS BHD 22                                                          7300120020
STRT                     -2        -14                               7300120024
WRIT3                    -1 6        2     A -90           3         7300120028
WRIT3 WT BHD 22 - LKG FWD                                      *     7300120032
LOAD                    F 22      F 22                               7300120036
INPE                                                                 7300129999
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

             SEVERITY = 0    INPUT IS STORED WITH REV. =   2

                                 INPUT IS EXECUTABLE
```

Fig. 11



TAPE NO. 730012 - 2 F 22000 **Fig. 12**

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

INPUT UPDATING          DATE  06/07/78    TIME  08/02/49     RUN NO.   29
JOB PB01  PROG. DEMO                 INPUT 0001    REV. NO.  31         PAGE   1

INPS                  N         1                                       7300010008
DRWG TRSV         FWD   F   7         F 12        F 17                  7300010016
RMKS WEBIFRMS. 7,12,17                                                  7300010020
STRT                                   -14                              7300010021
WRIT3                     -2 3                 A -90          3         7300010022
WRIT3 WEB FRM.        LKG. FWD                                   *      7300010023
LOAD                    F   7         F 17                              7300010049
INPE                                                                    7300019999
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

               SEVERITY = 0    INPUT IS STORED WITH REV. =  32

                                   INPUT IS EXECUTABLE
```

Fig. 13

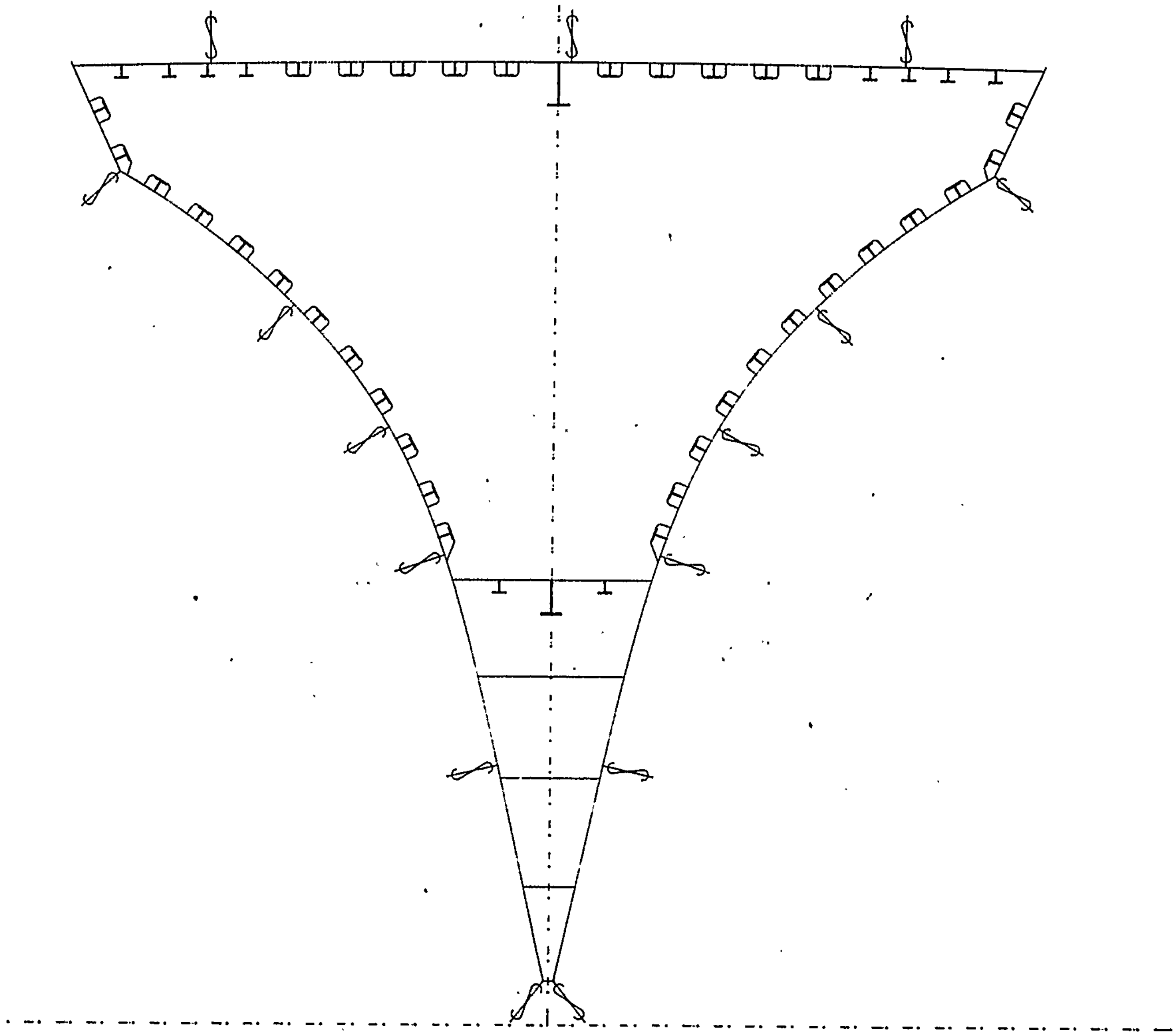
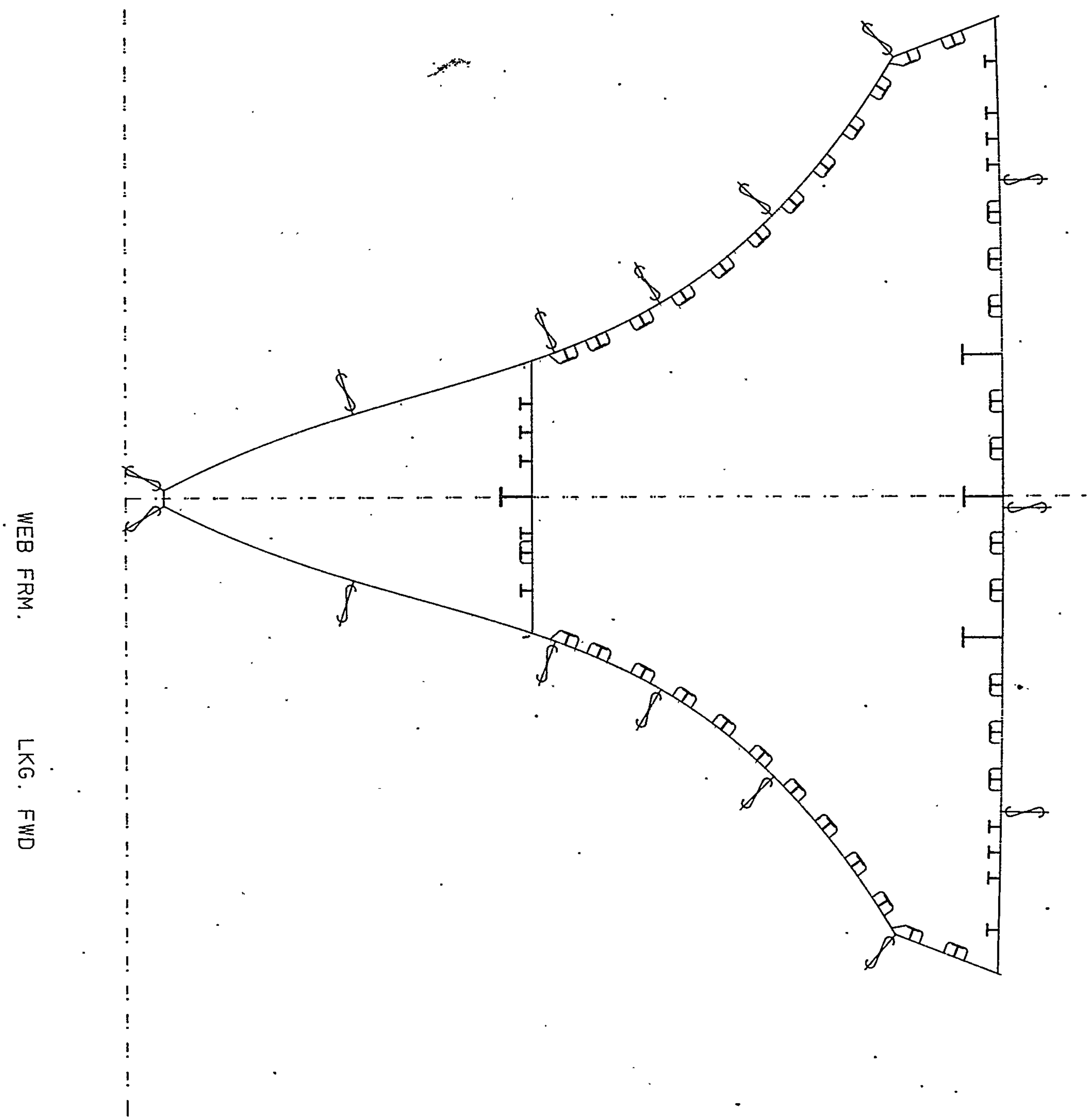
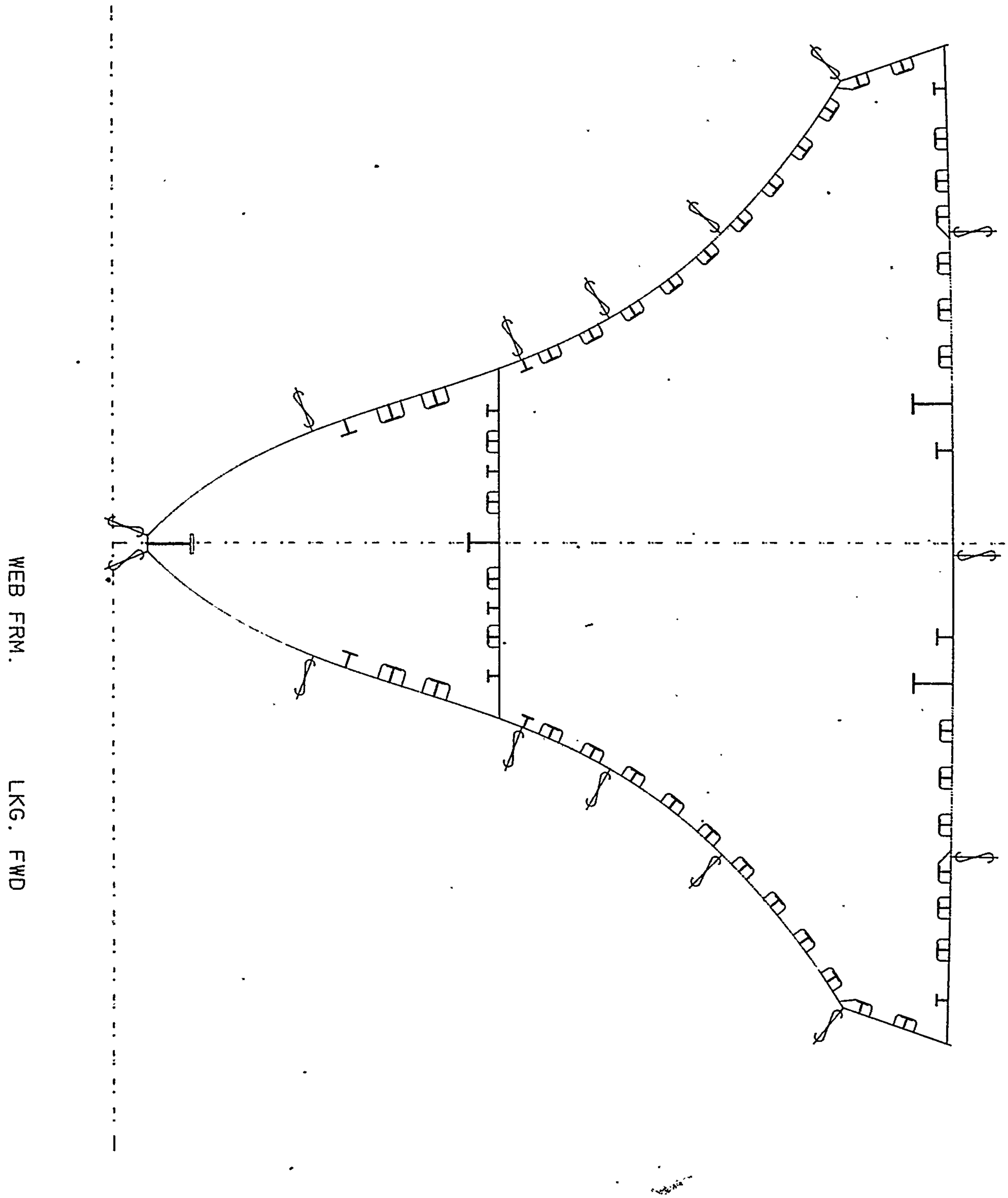


Fig. 14



TAPE NO. 731001 -17 F 12000 **Fig. 15**



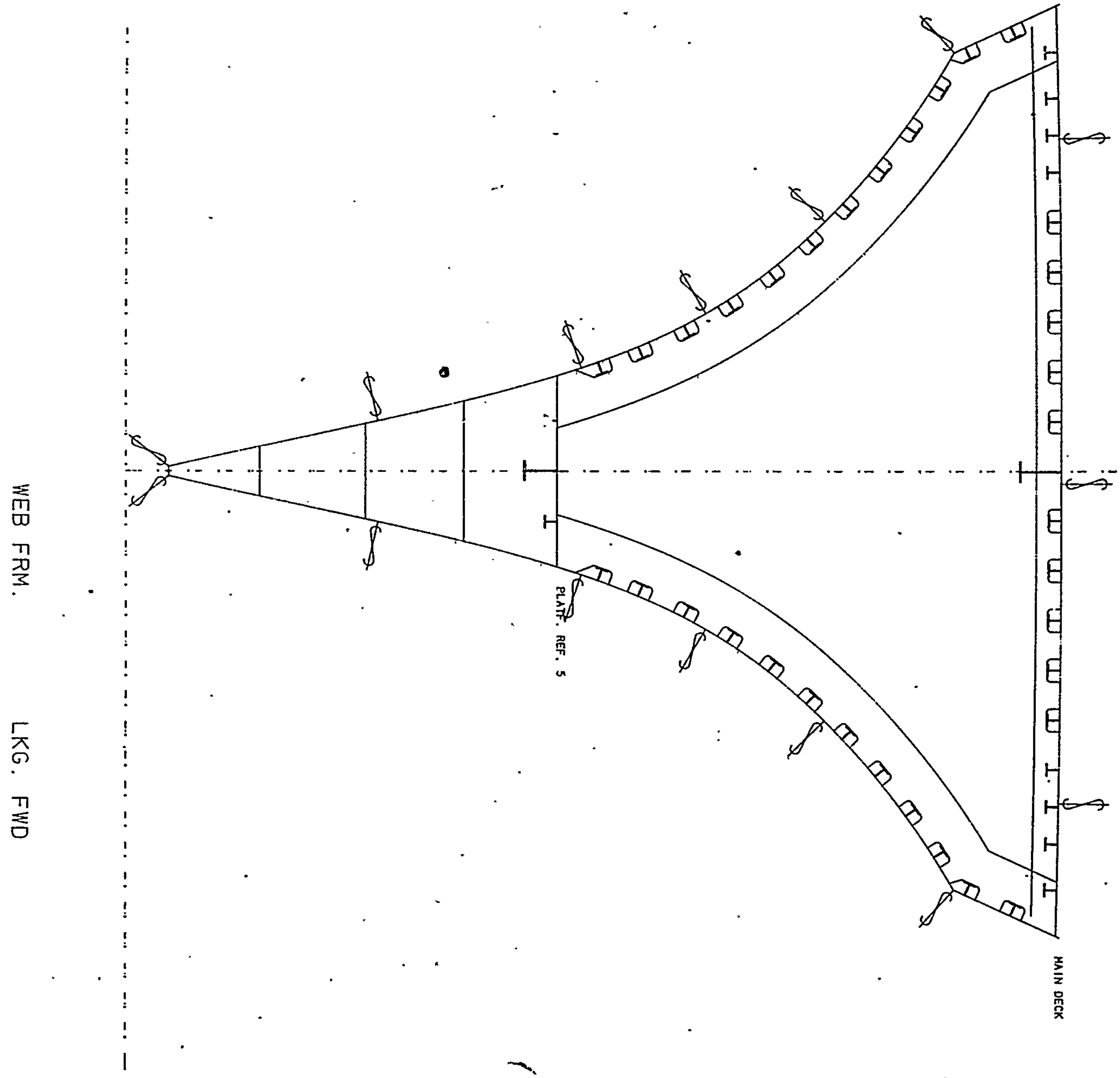
TAPE NO. 732001 -11 F 17000 **Fig. 16**

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

INPUT UPDATING          DATE  06/09/78    TIME  12/58/35     RUN NO.    9
JOB PB01  PROG. DEMO              INPUT 0002    REV. NO.  11        PAGE   1

INPS                  M       2                                      7300020008
DRWG TRSV        FWD   F  7      F 12      F 17                      7300020016C
RMKS WEBTFRMS. 7,12,17                                               7300020020
STRT                              -14                                7300020021
WRIT3                    -2 3             A -90           3          7300020022
WRIT3 WEB FRM.       LKG. FWD                                *       7300020023
MIDW                   M                                             7300020100
CNTR DOWNOUTP                                                        7300020104
SHEL2                  M         J B       D MDK                     7300020108
SHFT                       12             ANY-                       7300020112
                           12             ANY-                       7300020116
TRIM                 X D PFF                                         7300020120
TRIM2                X D MDK                                         7300020124
CTRE     INNL          M      P                                      7300020128
CNTR DOWNOUTP                                                        7300020132
SHEL2                  M         J B    S  D MDK  S                  7300020136
SHFT                       12             ANY+                       7300020140
                           12             ANY+                       7300020144
TRIM                 X D PFF                                         7300020148
TRIM2                X D MDK                                         7300020152
CTRE     INNL          M      S                                      7300020156
CNTR DOWNOUTP                                                        7300020160
DECK2                  D MDK     P END  S  P END  P                  7300020164
SHFT                        6             ANX-                       7300020168
                            6             ANX-                       7300020172
TRIM                 Y S L22  S                                      7300020176
TRIM2                Y S L22  P                                      7300020180
CTRE     INNL          D MDK                                         7300020184
WRIT3                  D MDK  S           A -90           2          7300020188
WRIT3   MAIN DECK                                            *       7300020192
WRIT3                  D PFF  S           A -90           2          7300020196
WRIT3   PLATF. REF. 5                                        *       7300020200
LOAD                   F  7      F  7                                7300020202
ADDP                   S CVK  C                20              1     7300020204
                      P       1                12              2     7300020208
                      P       2                12              3     7300020212
                      P       3                 6              4     7300020216
                      P       4                 6              5     7300020220
                      P       5                 6              6     7300020224
                      P       6                 6              7     7300020228
                      P       7                 6              8     7300020232
                      P       8                 6              9     7300020236
HOLE DOWN             P       2           A   0                      7300020240
                           18        15                              7300020244
HOLE                  P       4                                      7300020248
                            6                                        7300020252
HOLE                  P       6                                      7300020256
                            6                                        7300020260
HOLE                  P       8                                      7300020264
                            6                                        7300020268
CNTR     CALC                                                        7300020272
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

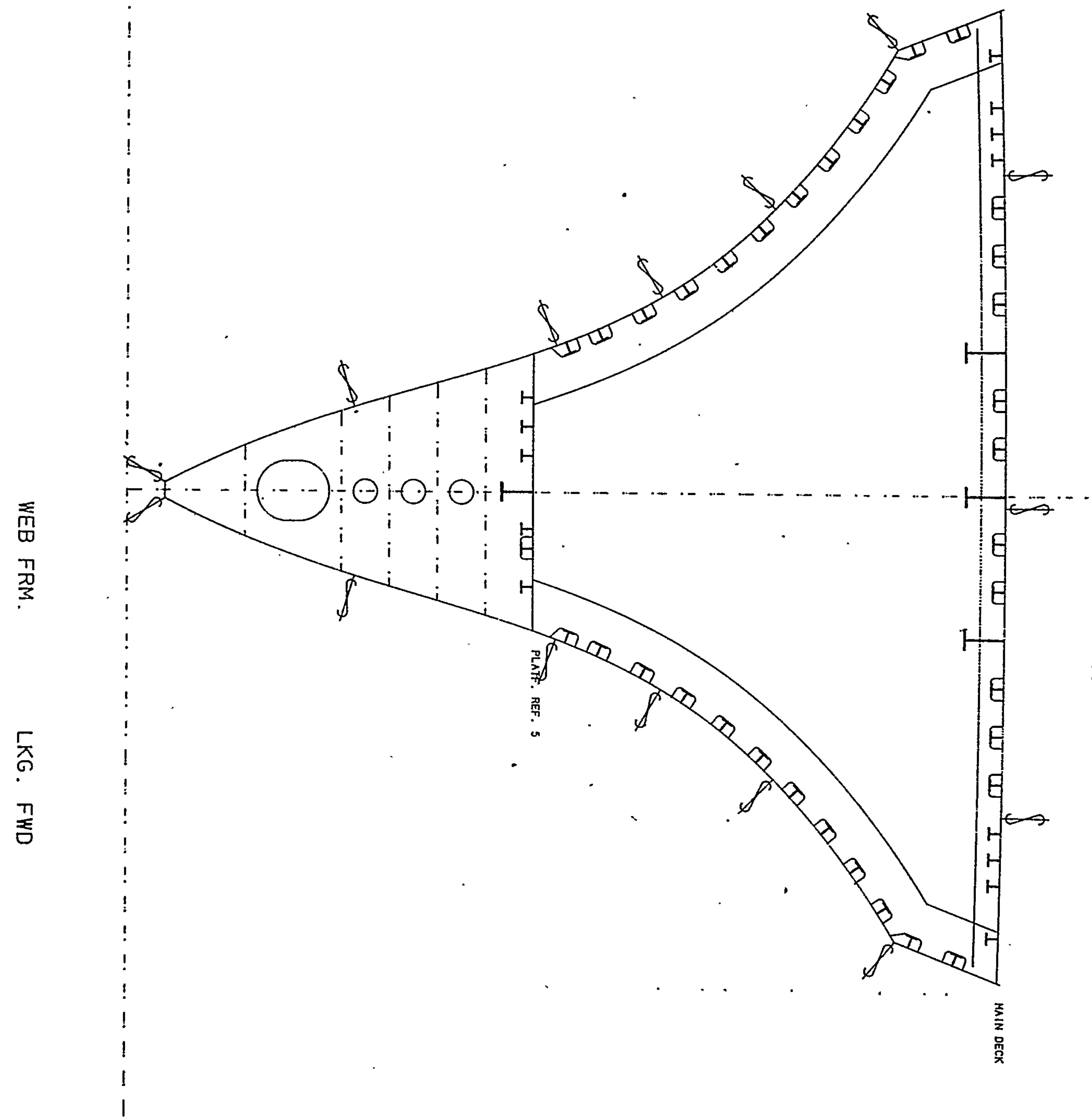
Fig. 17A

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

INPUT UPDATING          DATE  06/09/78    TIME  12/58/35     RUN NO.    9
JOB P801  PROG. DEMO              INPUT 0002    REV. NO.  11        PAGE   2

SHEL             P+    M                                             7300020276
SLPE2                XX       1                                    1 7300020280
    2                XX       3                                    3 7300020284
    2                XX       5                                    5 7300020288
    2                XX       7                                    7 7300020292
    2                XX       9                                    9 7300020296
CTRE     NOCT          M                                             7300020300
PNCH3                 P       1           X       1-Y       1        7300020304
PNCH3                 P       3           X       3-Y       3        7300020308
PNCH3                 P       5           X       5-Y       5        7300020312
PNCH3                 P       7           X       7-Y       7        7300020316
PNCH3                 P       9           X       9-Y       9        7300020320
LOAD                   F 12      F 17                                7300020400
INPE                                                                 7300029999
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

               SEVERITY = 0    INPUT IS STORED WITH REV. =  12

                                  INPUT IS EXECUTABLE
```

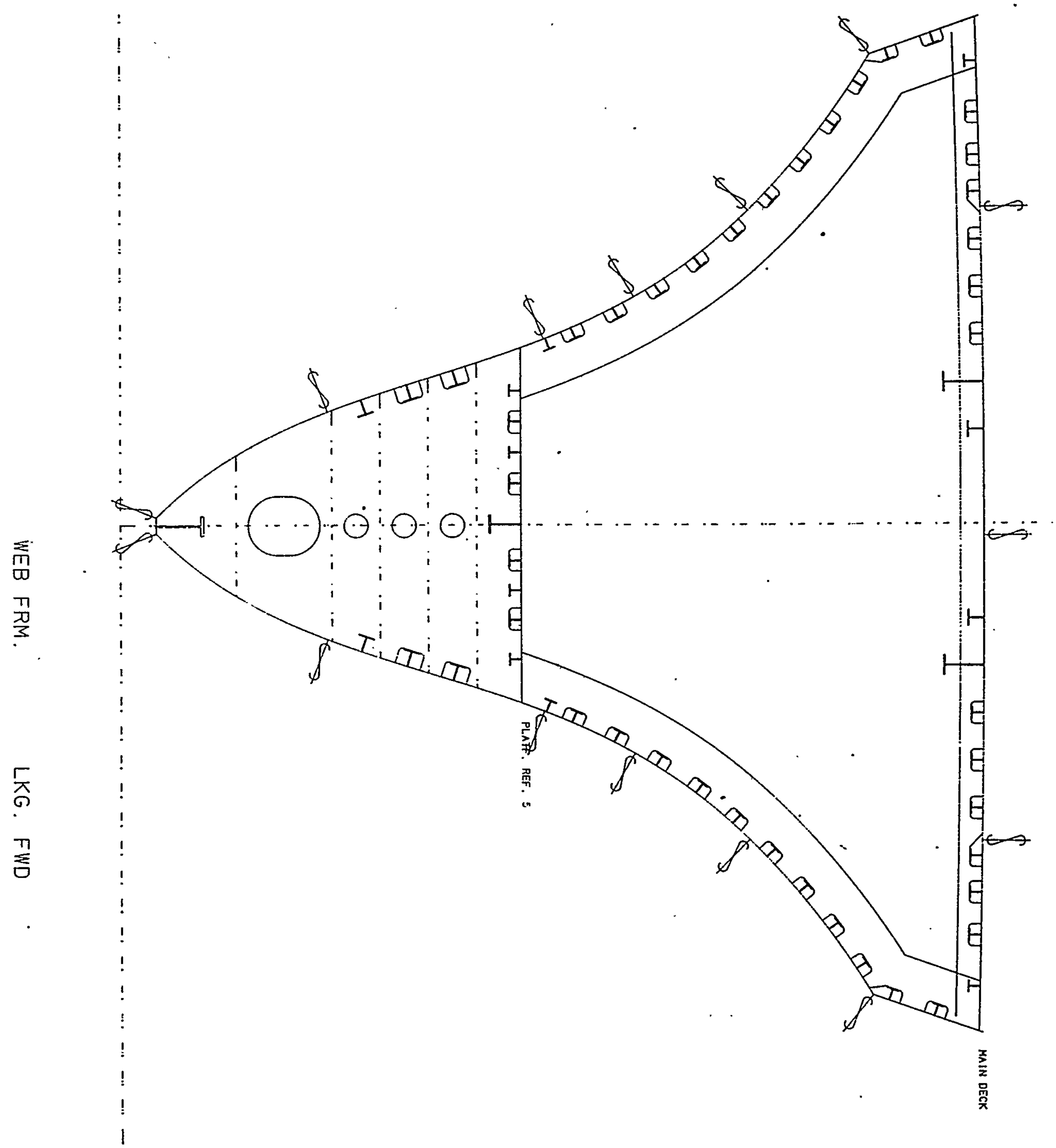
Fig. 17b



TAPE NO. 730002 - 9 F 7000 **Fig. 18**



TAPE NO. 731002 - 3 F 12000P **Fig. 19**



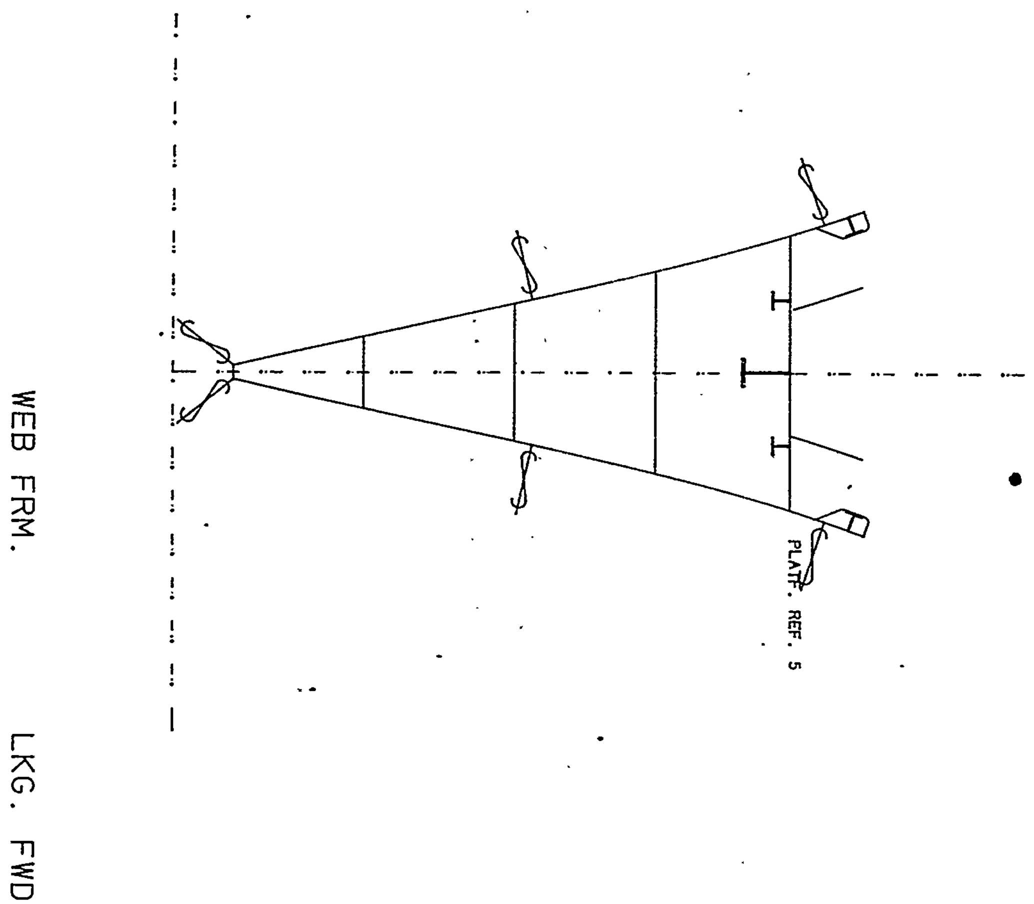
TAPE NO. 732002 - 3 F 17000P **Fig. 20**

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

INPUT UPDATING              DATE  06/07/76    TIME  08/02/54     RUN NO.    2
JOB PB01  PROG. DEMO                 INPUT 0004     REV. NO. . 2         PAGE   1

INPS                       N      4                                      7300040008
DRWG TRSV         FWD  F   7       F 12       F 17                       7300040016
RMKS WEBTFRMS. 7,12,17                                                   7300040020
STRT                                 -14                                 7300040021
WRIT3                        -2 3          A -90          3              7300040022
WRIT3 WEB FRM.         LKG. FWD                              *           7300040023
MION                    M                                                7300040100
ADDP                    D PFF   S                1              11       7300040102
LIMI                                      XX        11                   7300040103
CNTR DOWNOUTP                                                            7300040104
SHEL2                   M          J B        D MDK                      7300040108
SHFT                        12            ANY-                           7300040112
                            12            ANY-                           7300040116
TRIM                  X D PFF                                            7300040120
TRIM2                 X D MDK                                            7300040124
CTRE      INNL          M      P                                         7300040128
CNTR DOWNOUTP                                                            7300040132
SHEL2                   M .        J B    S   D MDK   S                  7300040136
SHFT                        12            ANY+                           7300040140
                            12            ANY+                           7300040144
TRIM                  X D PFF                                            7300040148
TRIM2                 X D MDK                                            7300040152
CTRE      INNL          M      S                                         7300040156
CNTR DOWNOUTP                                                            7300040160
DECK2                   D MDK      P END  S   P END  P                   7300040164
SHFT                         6            ANX-                           7300040168
                             6            ANX-                           7300040172
TRIM                  Y S L22  S                                         7300040176
TRIM2                 Y S L22  P                                         7300040180
CTRE      INNL          D MDK                                            7300040184
                                                                         7300040188D
                                                                         7300040192D
WRIT3                   D PFF  S           A -90          2              7300040196
WRIT3    PLATF. REF. 5                                       *           7300040200
LOAD                    F  7       F  7                                  7300040202
ADDP                    S CVK  C                 20               1      7300040204
                       P       1                 12               2      7300040208
                       P       2                 12               3      7300040212
                       P       3                  6               4      7300040216
                       P       4                  6               5      7300040220
                       P       5                  6               6      7300040224
                       P       6                  6               7      7300040228
                       P       7                  6               8      7300040232
                       P       8                  6               9      7300040236
HOLE DOWN              P       2           A   0                         7300040240
                           16        15                                  7300040244
HOLE                   P       4                                         7300040248
                             6                                           7300040252
HOLE                   P       6                                         7300040256
                             6                                           7300040260
HOLE                   P       8                                         7300040264
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Fig. 21a

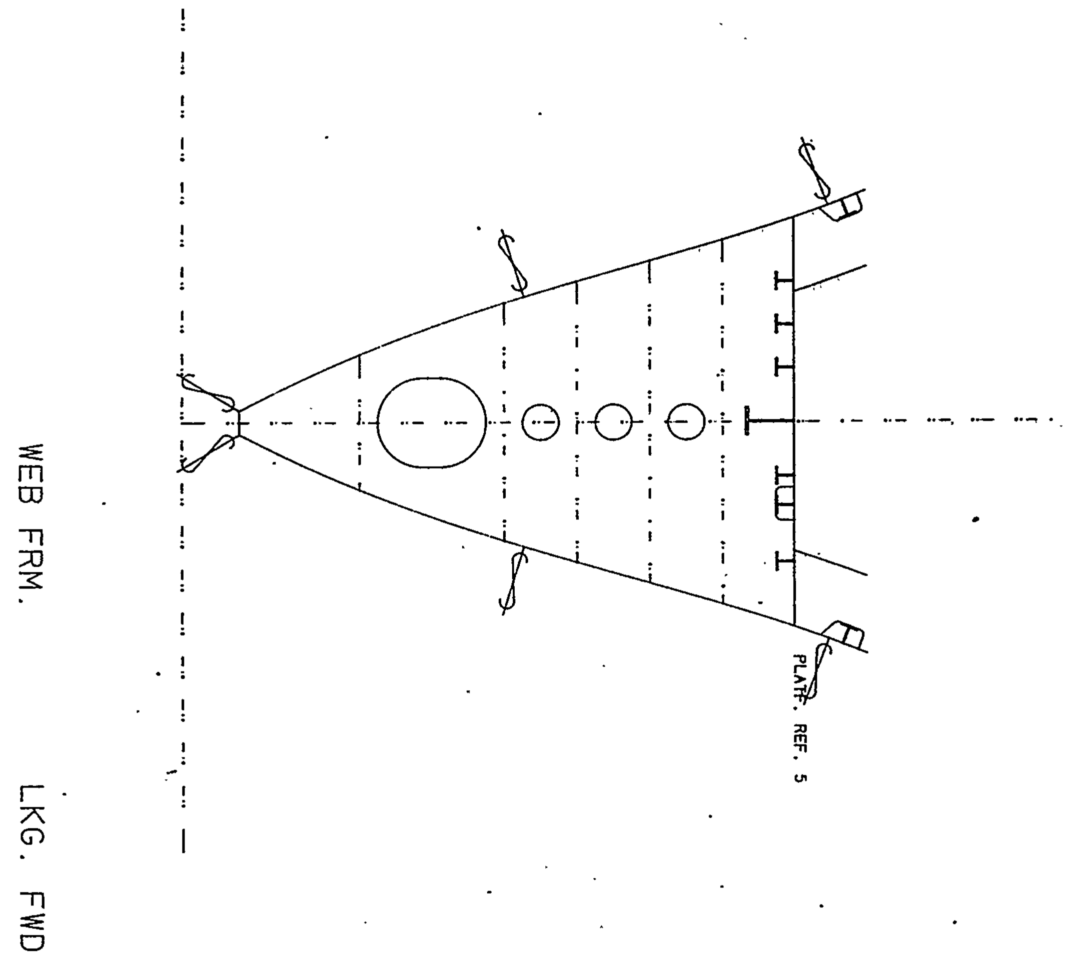
```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

INPUT UPDATING          DATE  06/07/78    TIME  08/02/54     RUN NO.     2
JOB PB01  PROG. DEMO              INPUT 0004    REV. NO.   2        PAGE   2

                            6                                        7300040268
CNTR     CALC                                                        7300040272
SHEL            P+    M                                              7300040276
SLPE2                XX       1                                    1 7300040280
    2                XX       3                                    3 7300040284
    2                XX       5                                    5 7300040288
    2                XX       7                                    7 7300040292
    2                XX       9                                    9 7300040296
CTRE     NOCT          M                                             7300040300
PNCH3                 P       1           X       1-Y       1        7300040304
PNCH3                 P       3           X       3-Y       3        7300040308
PNCH3                 P       5           X       5-Y       5        7300040312
PNCH3                 P       7           X       7-Y       7        7300040316
PNCH3                 P       9           X       9-Y       9        7300040320
LOAD                   F 12      F 17                                7300040400
INPE                                                                 7300049999
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

               SEVERITY = 0    INPLT IS STORED WITH REV. =   3

                                  INPUT IS EXECUTABLE
```

Fig. 21b



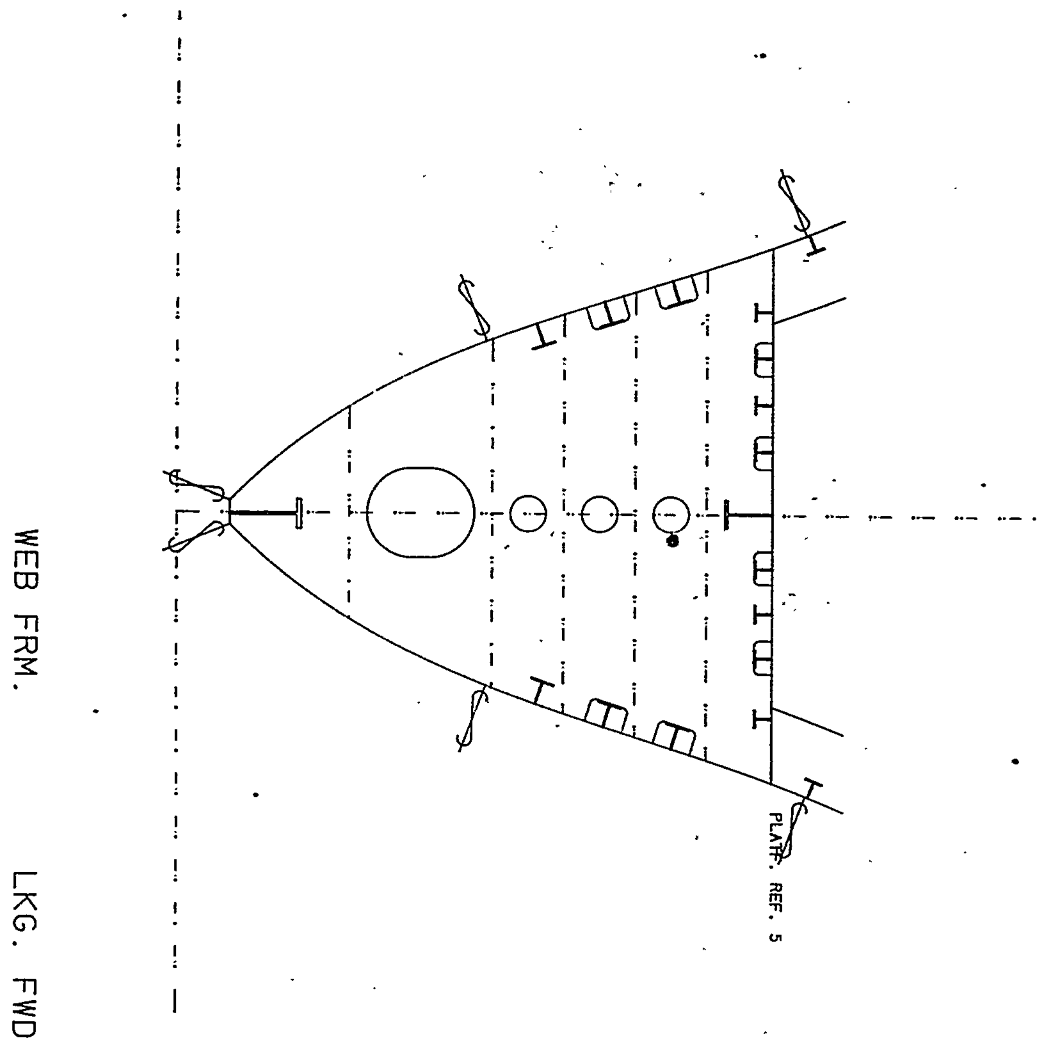
TAPE NO. 730004 - 1 F 7000

Fig. 22



TAPE NO. 731004 - 1 F 12000P

Fig. 23



TAPE NO. 732004 - 1 F 17000P

Fig. 24.

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

INPUT UPDATING           DATE  06/13/78    TIME  22/41/25     RUN NO.    9
JOB PB01  PROG. DEMO                INPUT 0003    REV. NO.   9         PAGE   1

INPS                 N       3                                        7300030008
DRAG TRSV        FWD    F  7                                          7300030012
RMKS DETAIL 14 D                                                      7300030016
MION                 M                                                7300030020
ADOP                  J F    S               12        06    1        7300030024
                      J F    S              -12        24    2        7300030028
                      J F    S              -12       -12    3        7300030030
LIMT                XX       3YY      3XX       1YY       1           7300030032
STRT                 P       3                                        7300030034
WRIT3                P       2         A -90          012             7300030036
WRIT3DETAIL 14D  SCALE3IN = 1FT                           *           7300030040
LOAD                  F  7      F  7                                  7300030044
INPE                                                                  7300039999
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

             SEVERITY = 0    INPUT IS STORED WITH REV. =  10

                             INPUT IS EXECUTABLE
```

Fig. 25

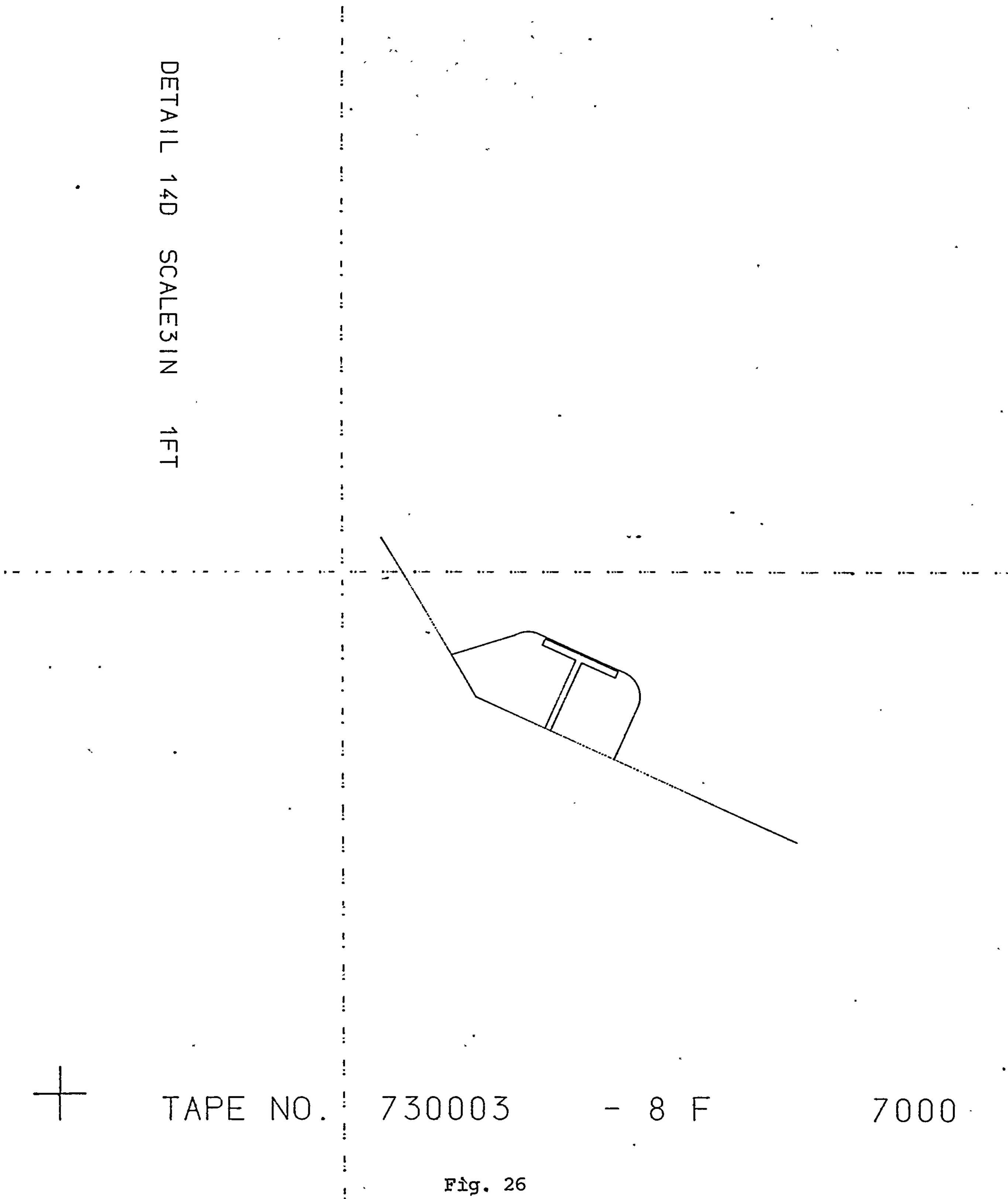
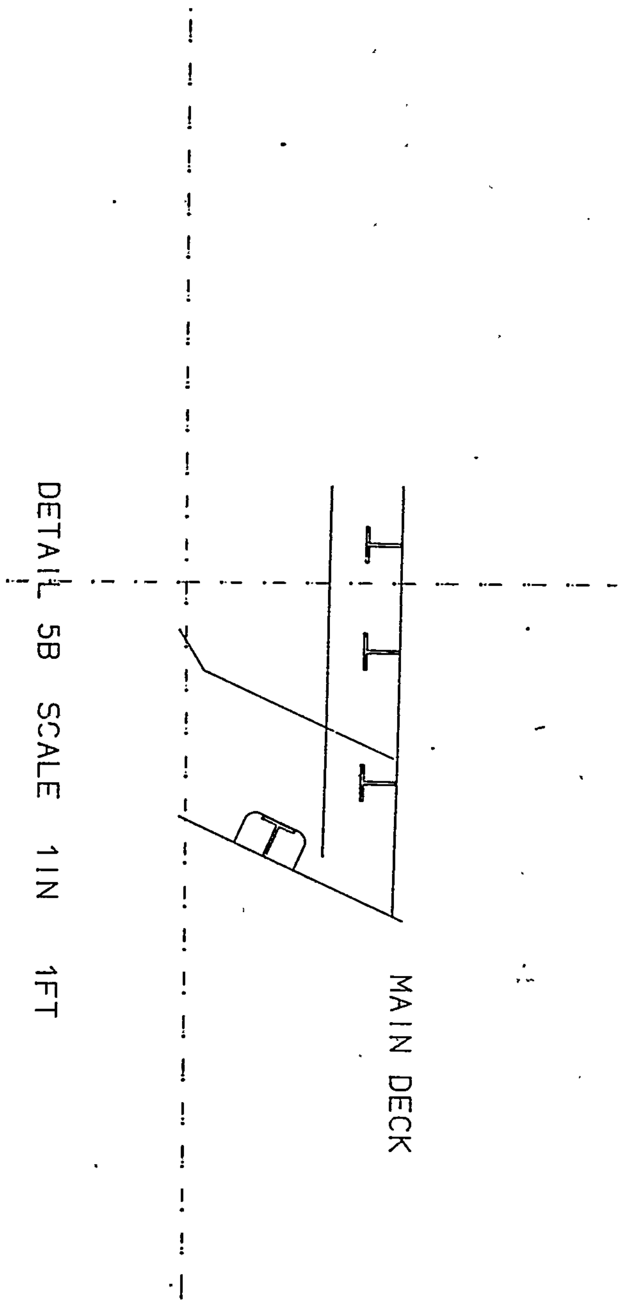


Fig. 26

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

INPUT UPDATING         DATE  06/09/78    TIME  08/26/06     RUN NO.   6
JOB PB01  PROG. DEMO                INPUT 0005    REV. NO.   6        PAGE   1

INPS                  N      5                                       7300050008
DRWG TRSV        FWD   F  7                                          7300050016
RMKS WEBTFRMS. 7,12,17                                               7300050020
MIDN                   M                                             7300050100
ADDP                   D MDK  S               -18       3      1     7300050104
ADDP                   D MDK  S                1       -3      3     7300050105C
LIMT                 XX      1YY      3XX       3YY       1          7300050106
STRT                  X      1 Y      3                              7300050108
ADDP                  P      1                -12              2     7300050112
WRIT3                 P      2          A -90         2              7300050116
WRIT3DETAIL 5B  SCALE  1IN = 1FT                         *           7300050120
CNTR DOWNOUTP                                                        7300050132
SHEL2                  M          J B    S  D MDK  S                 7300050136
SHFT                       12           ANY+                         7300050140
                           12           ANY+                         7300050144
TRIM                 X D PFF                                         7300050148
TRIM2                X D MDK                                         7300050152
CTRE      INNL         M      S                                      7300050156
CNTR DOWNOUTP                                                        7300050160
DECK2                  D MDK      P END  S  P END  P                 7300050164
SHFT                        6           ANX-                         7300050168
                            6           ANX-                         7300050172
TRIM                 Y S L22  S                                      7300050176
TRIM2                Y S L22  P                                      7300050180
CTRE      INNL         D MDK                                         7300050184
WRIT3                  D MDK  S         A -90         2              7300050188
WRIT3   MAIN DECK                                        *           7300050192
LOAD                   F  7       F  7                               7300050202
INPE                                                                 7300059999
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

               SEVERITY = 0    INPUT IS STORED WITH REV. =   7


                                INPUT IS EXECUTABLE
```



TAPE NO. 730005 - 4 F 7000

Fig. 28

```
         1         2         3         4         5         6         7
12345678901234567890123456789012345678901234567890123456789012345678901234567890

INPUT UPDATING          DATE  06/09/78    TIME  16/36/56     RUN NO.    7
JOB OILR  PROG. DEMO                INPUT 0018    REV. NO.  11          PAGE   1

INPS        16TH     N    0018                                          7300180008
RMKS BAUER TEST DEMO                                                    7300180020
LIMT                X    -1     YF -  01  X    50     Y   45            7300180112
STRT                      0         -1                                  7300180113
DRWG TRSV       FWD   F 30      F 31                                    7300180116
ADDP                     20      D   310 9                      3       7300180120
LINE FAST            P        3                                         7300180128
CNTR DOWNOUTP                                                           7300180132
DECK            P+    D MDK                                             7300180136
SHFT                      2 9               A 180                       7300180142
                          2 9               ANX-                        7300180144
SAVE                                                            1       7300180148
LINK    NEW                                                             7300180152
SHEL            P-    M                                                 7300180156
SHFT                      4 2               ANY-                        7300180160
                          4 2               ANX+                        7300180164
SAVE                                                            2       7300180168
LINK    NEW                                                             7300180172
MANU                 P        3                                         7300180176
LINE                     100     Y       3                              7300180180
ENDM                                                                    7300180184
LINK    RND               4 014                                         7300180188
CALL                                                            1       7300180192
LINK    RND               4 014                                         7300180200
CALL                                                            2       7300180204
LINK    RND               4 614                                         7300180208
MANU                     -20     Y       3                              7300180212
LINE                 P        3                                         7300180216
ENDM                                                                    7300180220
CTRE    HOLD          H 101                                             7300180224
LOAD                  F 30      F 31                                    7300180257
INPE    STOR                                                            7300189990
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

            SEVERITY = 0    INPUT IS STORED WITH REV. =  12
```

Fig. 29a

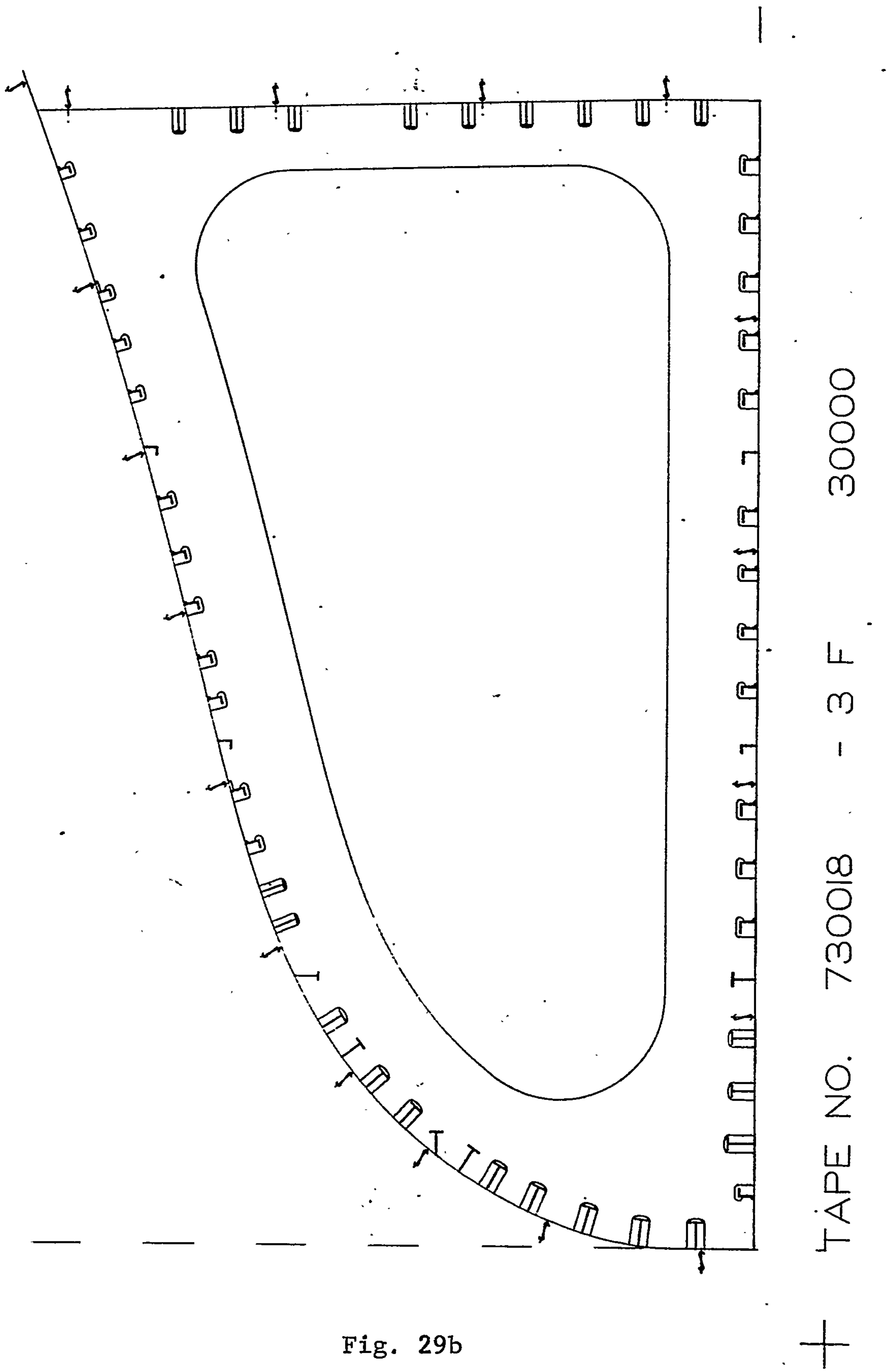
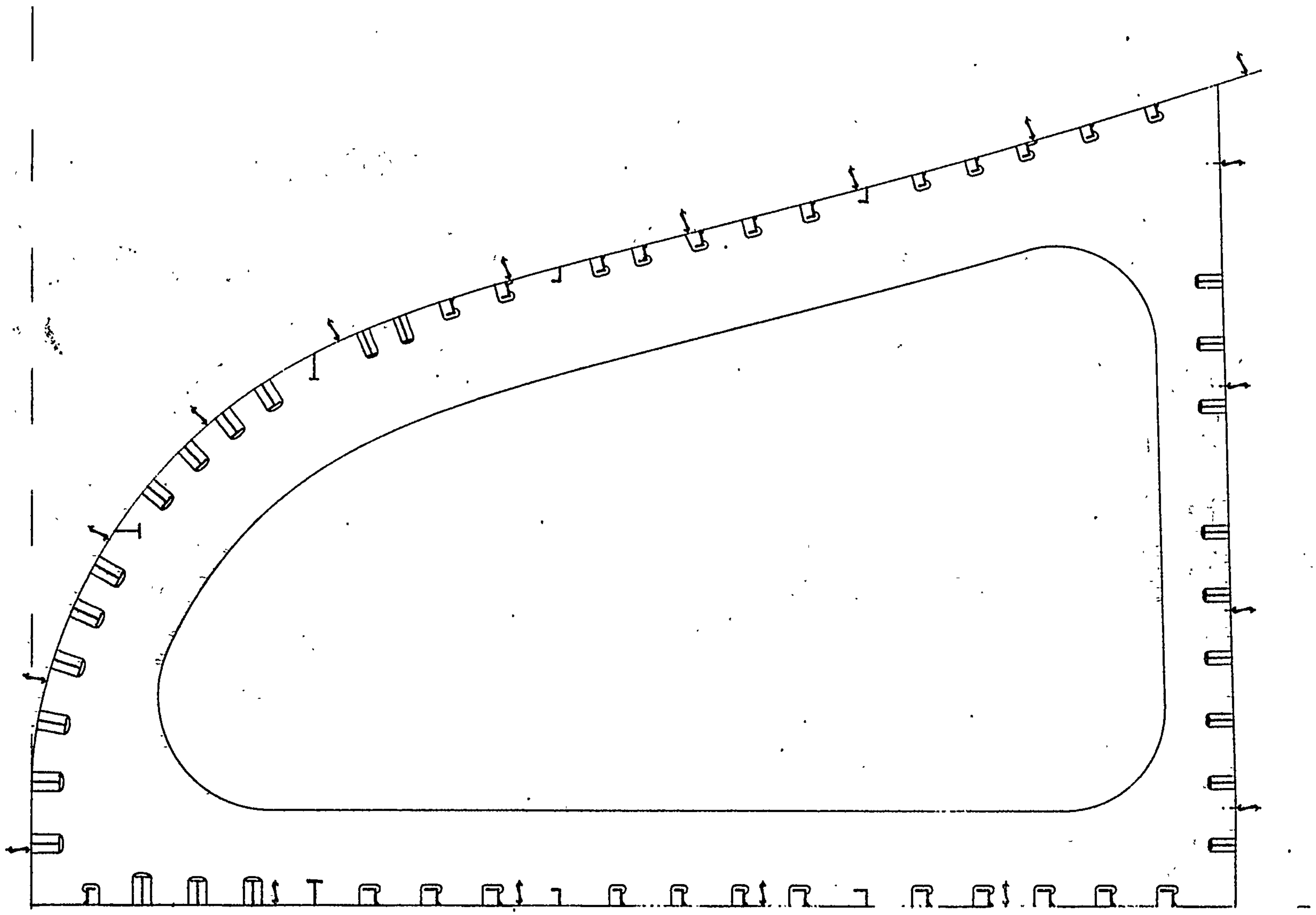


Fig. 29b

Fig. 29c



TAPE NO. 731018 - I F 31000

```
         1         2         3         4         5         6
1234567890123456789012345678901234567890123456789012345678901234567

INPUT UPDATING          DATE  06/14/78    TIME  16/36/22    RUN N
JOB WATR  PROG. DEMO                INPUT 0001    REV. NO.  20

INPS WATR                N    0001
LIMT                    X    -1     Y   -11     X    25     Y    55
DRWG TRSV          FWD   F 96
STRT                         0          -12
RMKS BAUER TEST DEMO
HOLE                        14 3        -9 6     A    0
                             7            15
                            13 3        12 6     A    0
                             7            15
                            13 6        18 6     A    0
                             5            15
                            14 3        21 6     A    0
                             5            15
                             3           1 8     A    0
                              23          15
MIDN                      M
STPT                      S  4                                    10
                          S  5                                    11
                          S  7                                    12
                          S  8                                    13
                          S 10                                    14
PNCH3                       20          11       P       10
    3                       20          14       P       11
    3                       20          20       P       12
    3                       20          23       P       13
    3                       20          29       P       14
LOAD                      F 96        F 96
INPE      STOR
         1         2         3         4         5         6
123456789012345678901234567890123456789012345678901234567890123456

                SEVERITY = 0    INPUT IS STORED WITH REV. =  21

                                    INPUT IS EXECUTABLE
```

Fig. 30a

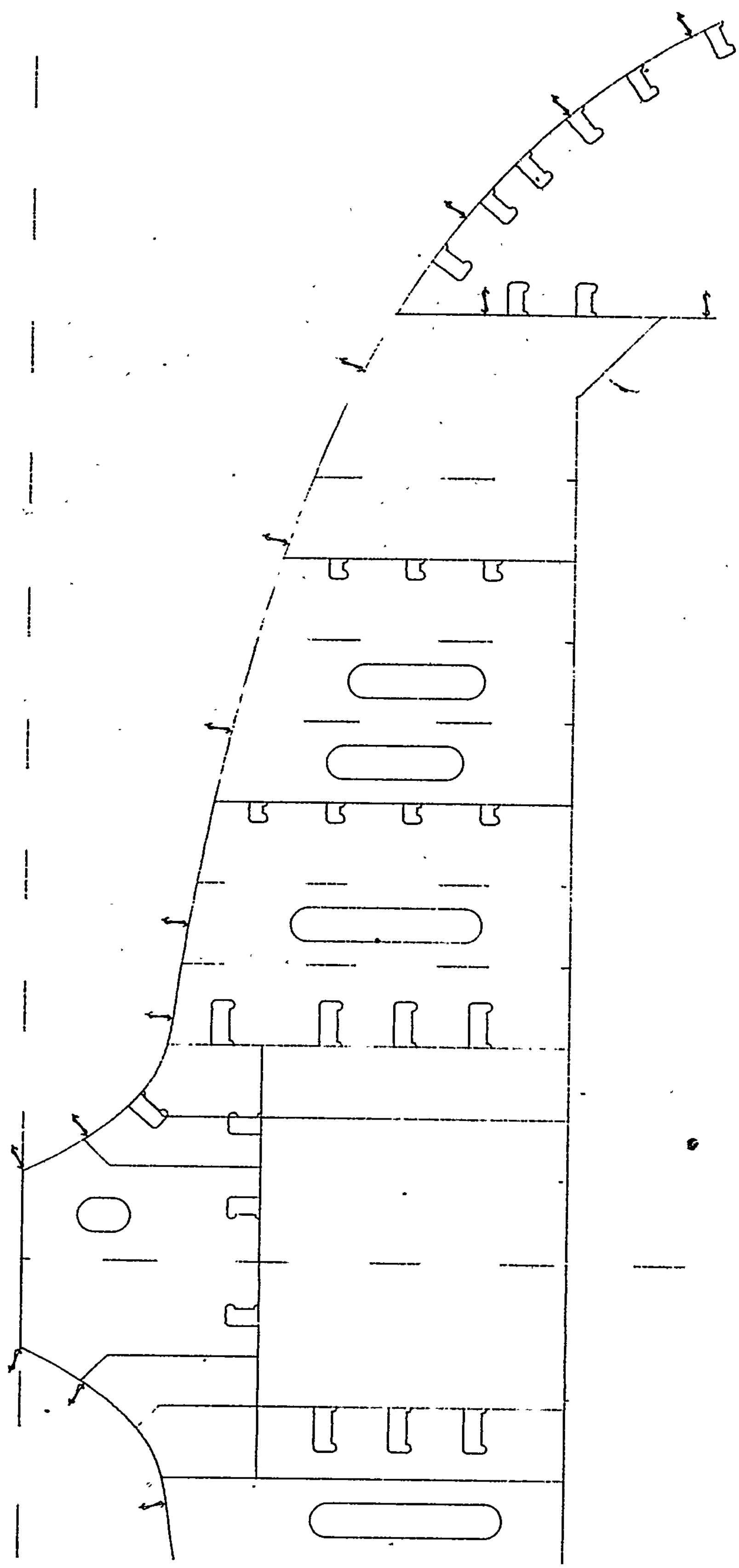
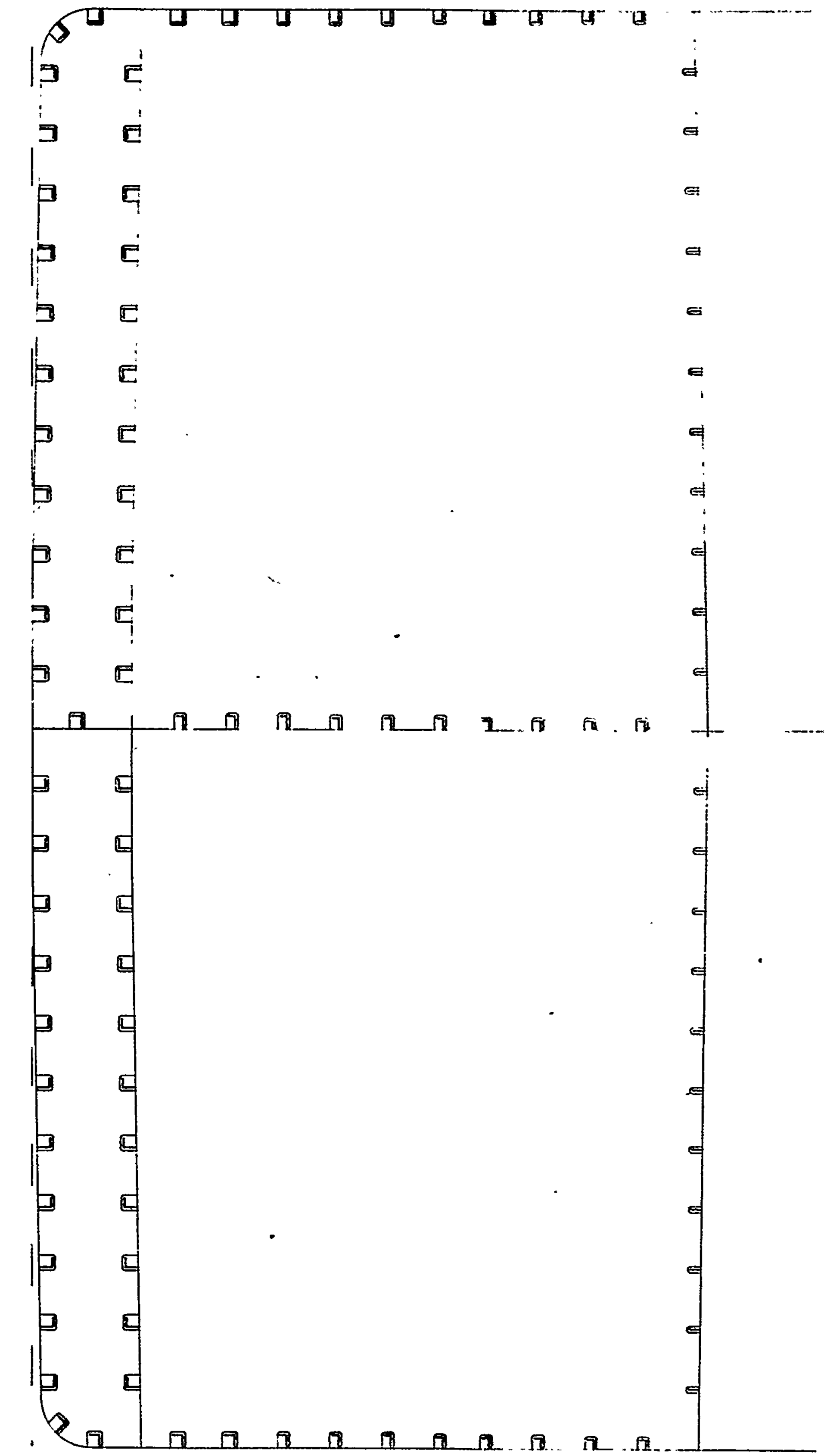


Fig. 30b

TAPE NO. 830001 -10 F 96000



TAPE NO. 1131001 - 3 F 14000 Fig. 31

Arnold G. Reinhold
Computervision Corporation
Bedford, Massachusetts

Mr. Reinhold is Product Line Manager, Civil Engineering and Mapping Systems at Computervision. He is product line manager for computer graphics systems for architecture, piping and cartography. Mr. Reinhold has 7 years of experience in programming and software management, primarily in computer graphics.

lie has a B.S. degree in mathematics from City College of New York, an A.B.D. in mathematics from M.I.T., and a M.B.A. from Harvard.

THREE GENERATIONS OF COMPUTER ASSIST TO PIPING

BATCH SYSTEMS

INTERACTIVE DRAFTING SYSTEMS

INTERACTIVE DESIGN SYSTEMS

CHARACTERISTICS OF BATCH SYSTEMS

RECORD INPUT

CUMBERSOME EDITING

PIPING DATABASE

INFLEXIBLE OUTPUT

CHARACTERISTICS OF INTERACTIVE DRAFTING

EASY EDITING

ARCHIVE QUALITY PLOTS

LINES-ON-PAPER DATABASE

LIMITED DATA CAPTURE

LIMITED 3-D CAPABILITY

CHARACTERISTICS OF INTERACTIVE DESIGN

-BEST OF BOTH-

EASY EDITING

TRUE 3-D

GENERALIZED DATABASE

OUTPUT REPORT LANGUAGE

DESIGN RULES CHECKING

MULTI - APPLICATION

INTERFACE TO OTHER SYSTEMS

GENERALIZED DATABASE IS KEY TO GROWTH

GRAPHICAL DATA

NON-GRAPHICAL DATA

USER-DEFINED DATA

DATA INDEPENENCE

DATA EXTRACTION

3-D DESIGN PROCESS

STRUCTURE, COMPARTMENTALIZATION

MAJOR EQUIPMENT LOCATION

RUN LINES BASED ON SYSTEM SCHEMATIC

INSERT COMPONENTS

OUTPUTS FROM INTERACTIVE DESIGN SYSTEM

ARCHIVE QUALITY DRAWINGS

BILLS OF MATERIAL

FROM-TO LISTS

ISOMETRIC, ORTHOGRAPHY C, AND DETAIL PLOTS

MASS PROPERTIES

DATA FOR OTHER SYSTEMS

USER DEFINED REPORTS

OTHER COMPUTER SYSTEMS THAT CAN USE
DATA FROM INTERACTIVE DESIGN

BATCH PIPING

INTERFERENCE ANALYSIS

STRESS ANALYSIS

SIMULATION

MASS PROPERTIES ACCOUNTING

FINITE ELEMENT ANALYSIS

MULTI-APPLICATION-ADVANTAGES

PURCHASE ECONOMY

SHIFTING WORKLOAD

UNIFIED DATABASE

EASIER TRAINING

MULTI-APPLICATION-EXAMPLES

P I P I N G

WIRING DIAGRAMS

MECHANICAL DESIGN

S T R U C T U R A L

NUMERICAL CONTROL

FINITE ELEMENT MODELING

TECHNICAL ILLUSTRATION

P A R T   N E S T I N G

OFF-THE-SHELF VS CUSTOM BUILT SYSTEMS

ADVANTAGES OF OFF-THE-SHELF SYSTEMS

- LOWER COST
- READY AVAILABILITY
- SUPPORT AND DEVELOPMENT
- WIDE USER BASE

DISADVANTAGES

- DOESN'T DO EXACTLY WHAT YOU WANT

SOLUTION

- USER ADAPTABLE SYSTEMS

CONCLUSION

OFF-THE-SHELF THIRD GENERATION INTERACTIVE DESIGN SYSTEMS ARE THE RIGHT STARTING POINT FOR AUTOMATING THE SHIP PIPING DESIGN PROCESS

THE HITACHI HICAS SYSTEM

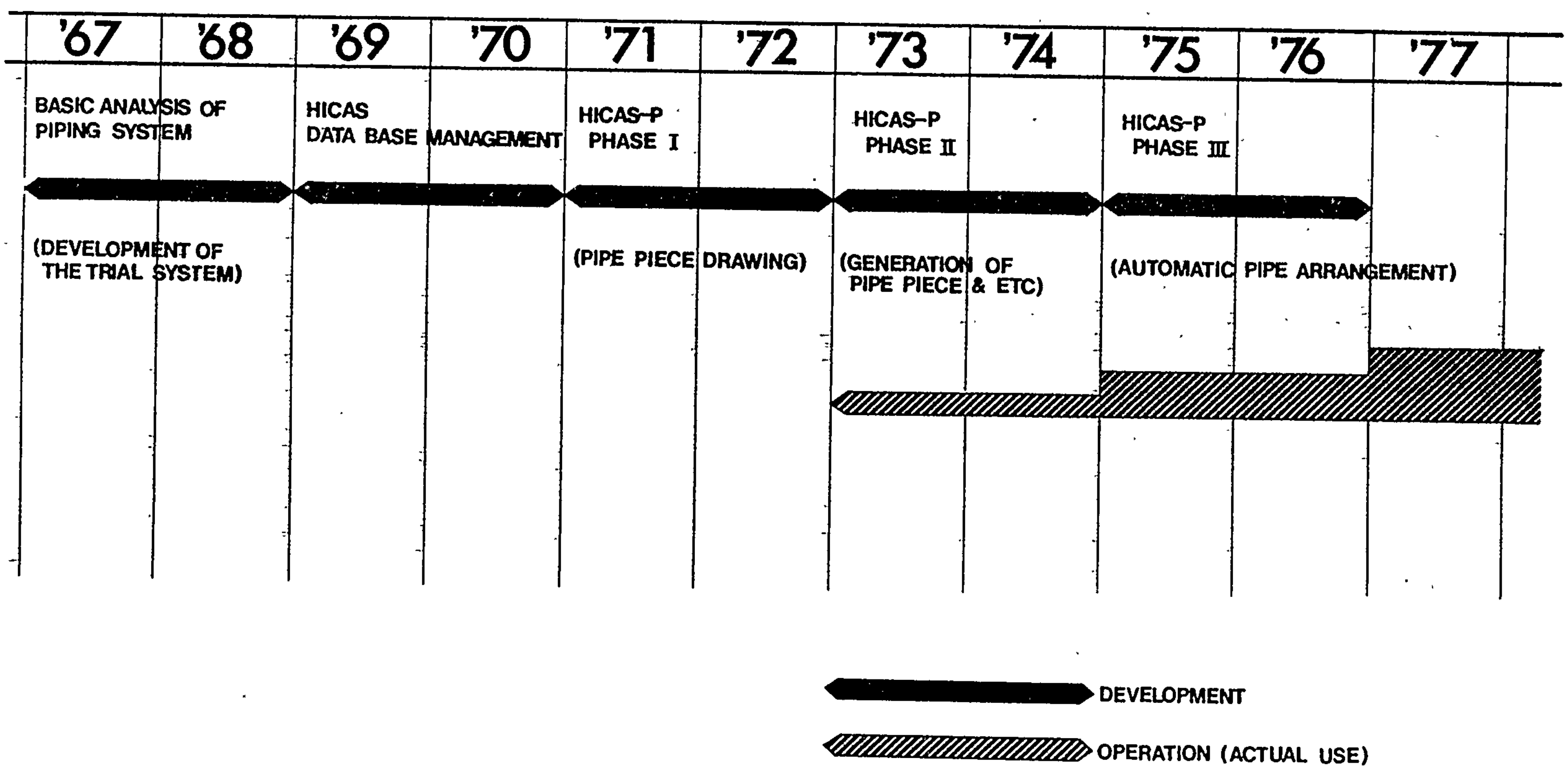
Masaru Ueda
Hitachi Zosen information Company, Ltd.
Tokyo, Japan

As Chief of the Applied Engineering section at Hitachi, Mr. Ueda is responsible for several applied engineering systems including a piping design system and an electrical cable system. His past experience involved planning and development of piping design computerization.

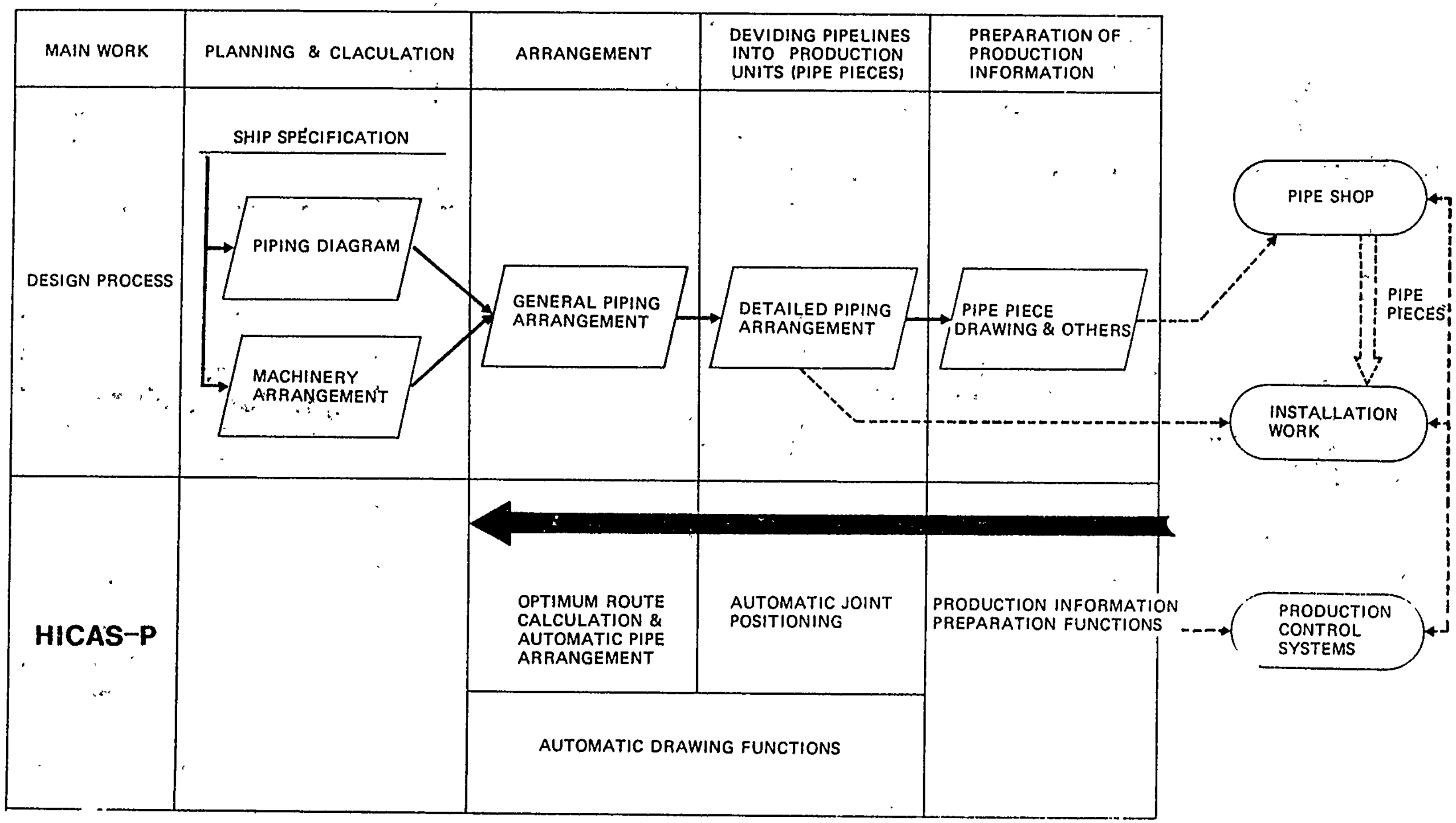
Mr. Ueda attended Osaka Prefecture University, Industrial Engineering Department.

HICAS-P

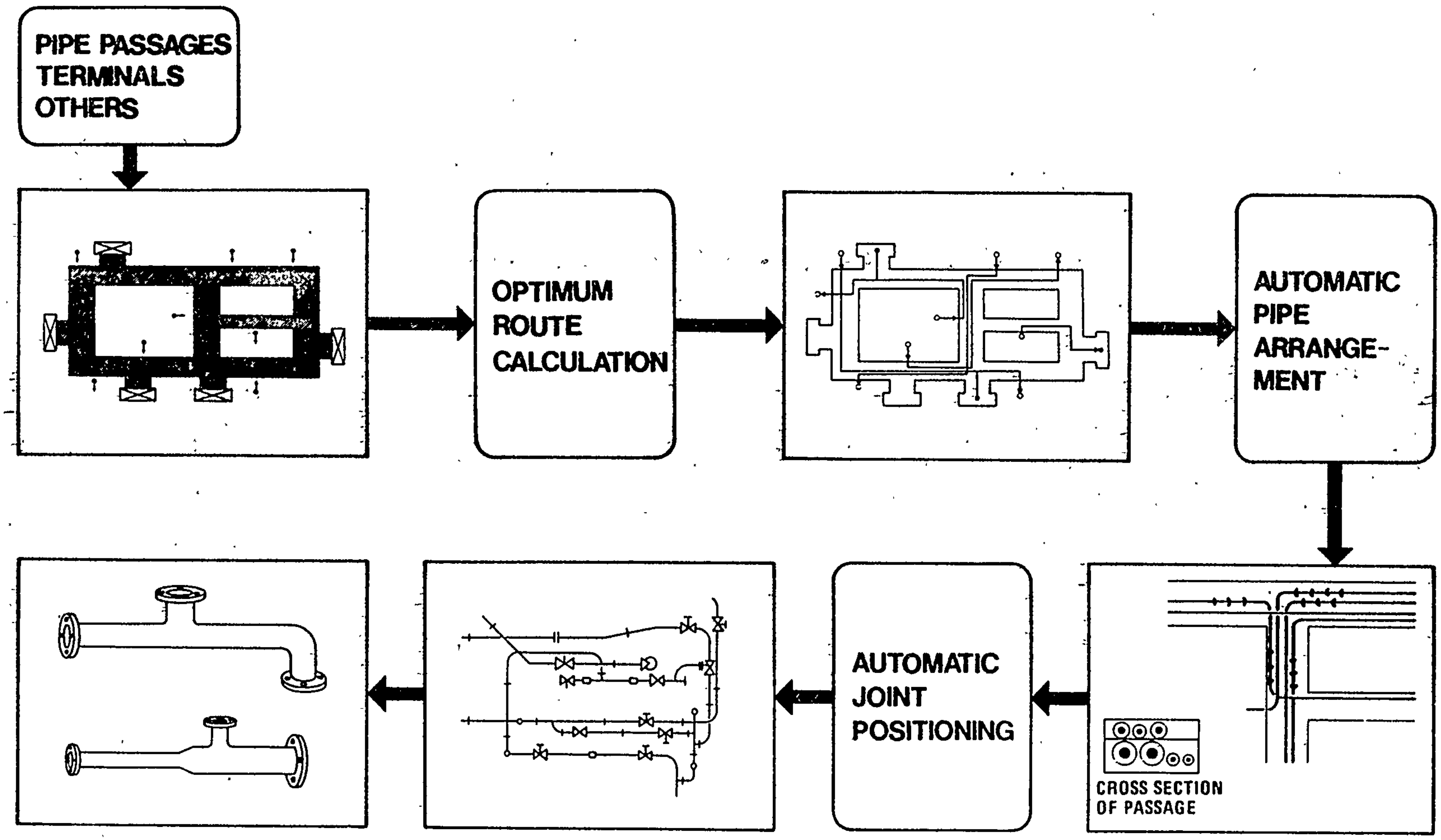
HISTORY



HICAS-P & DESIGN WORK

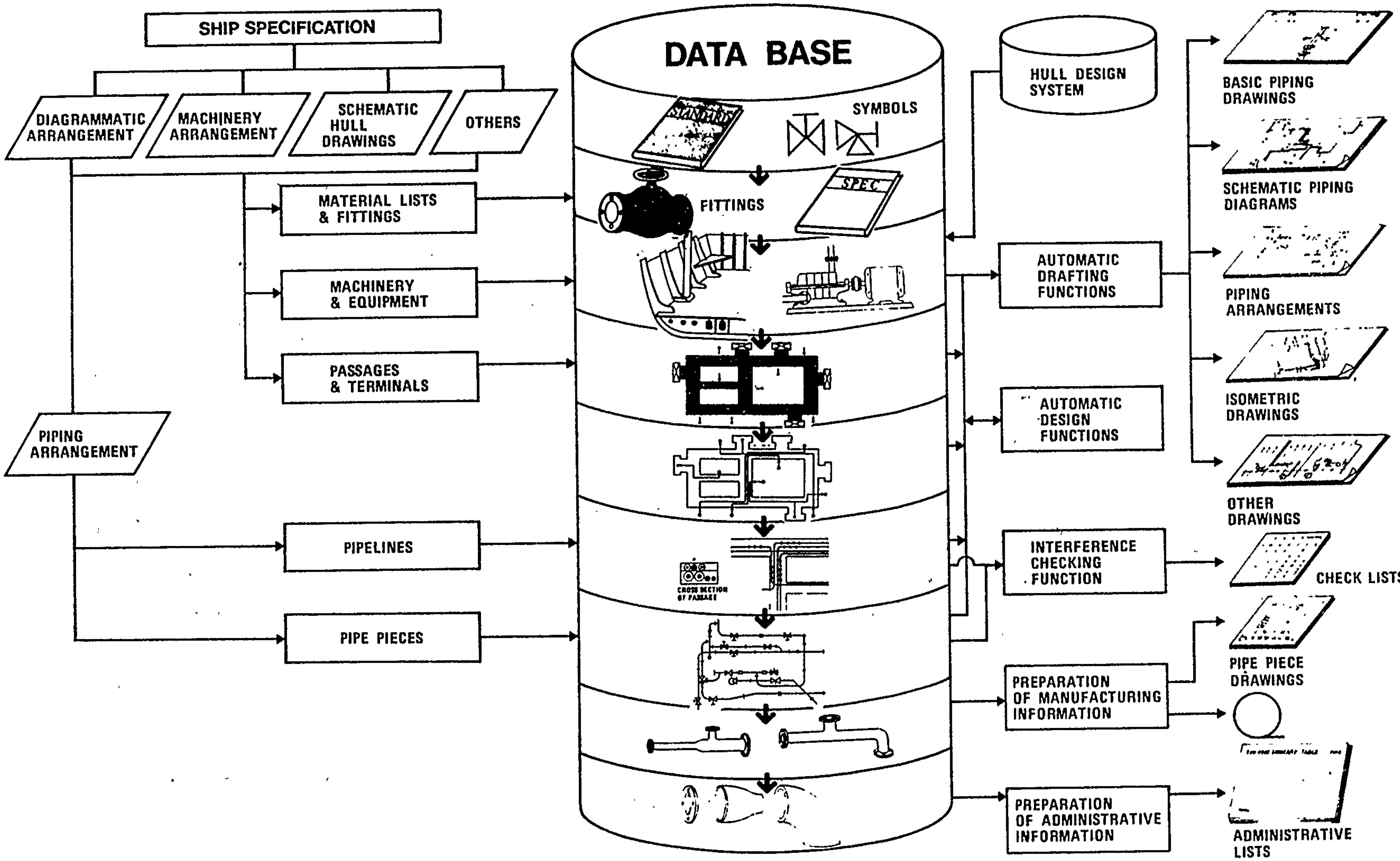


HICAS-P AUTOMATIC DESIGN FUNCTIONS

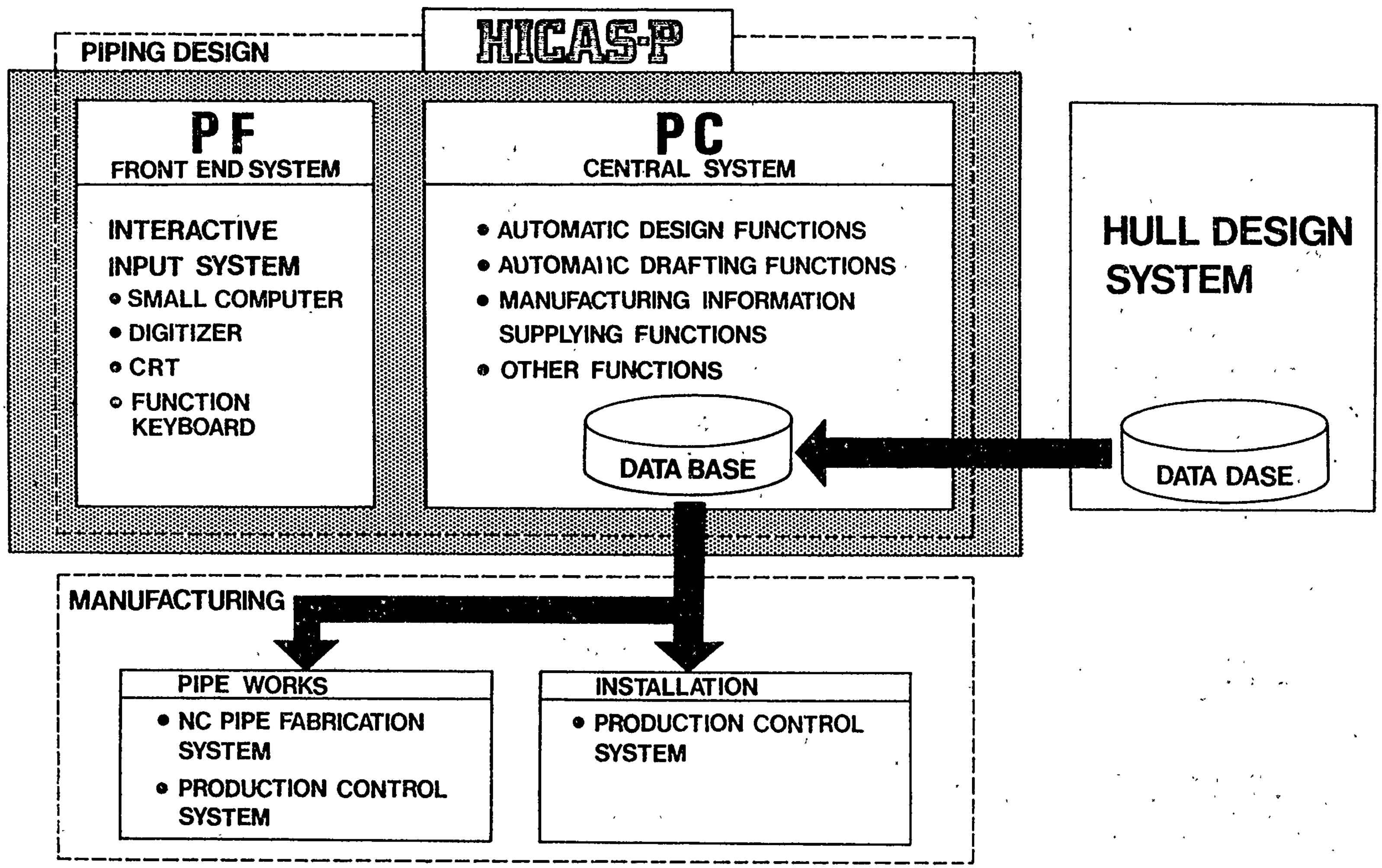


HICAS-P

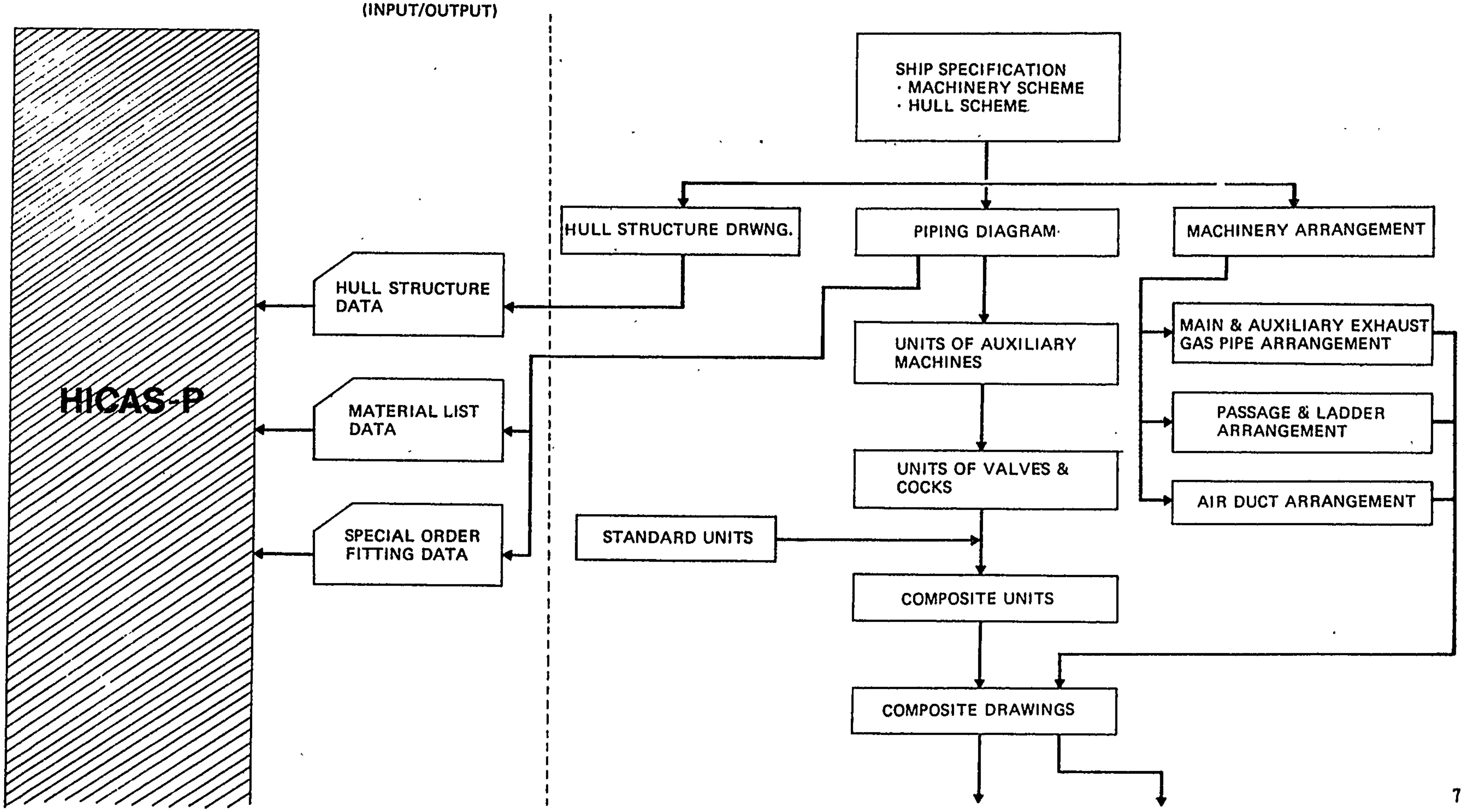
SYSTEM FLOW



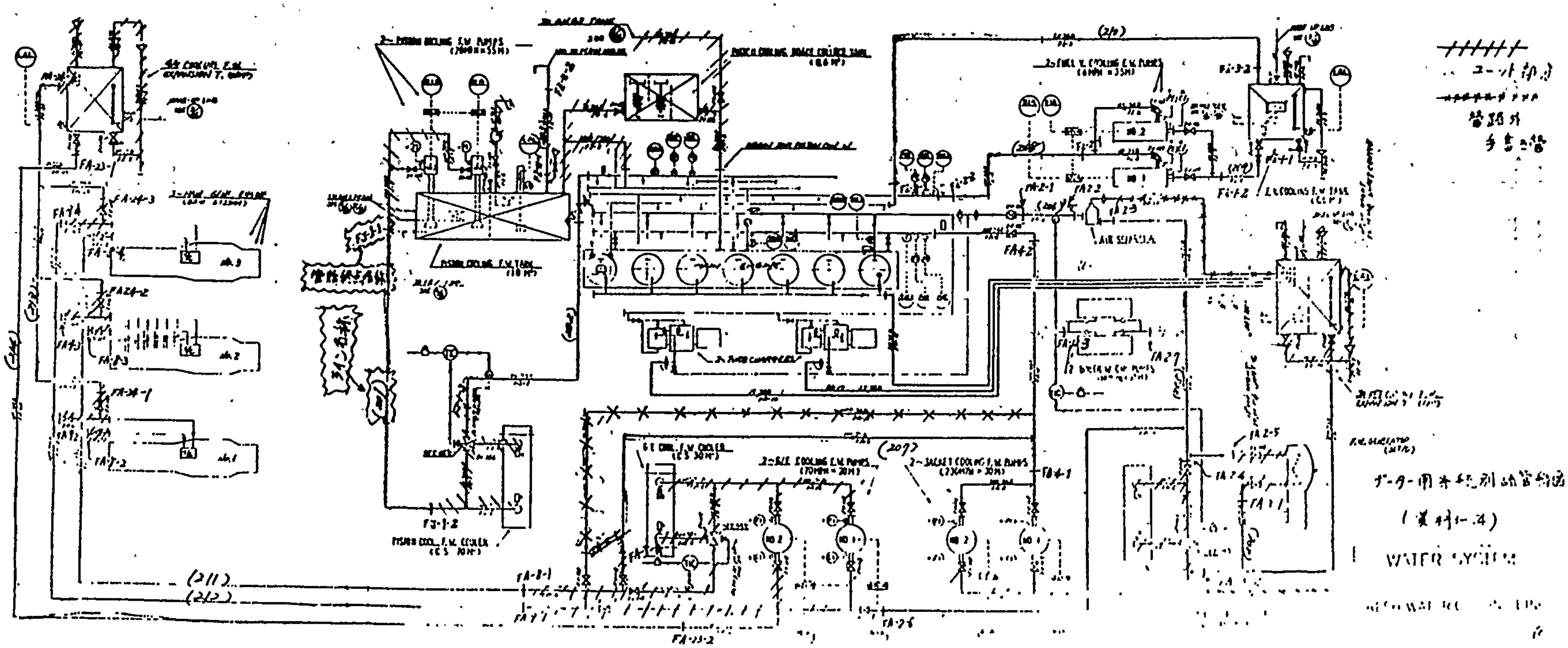
HICAS-P SYSTEM COMPOSITION



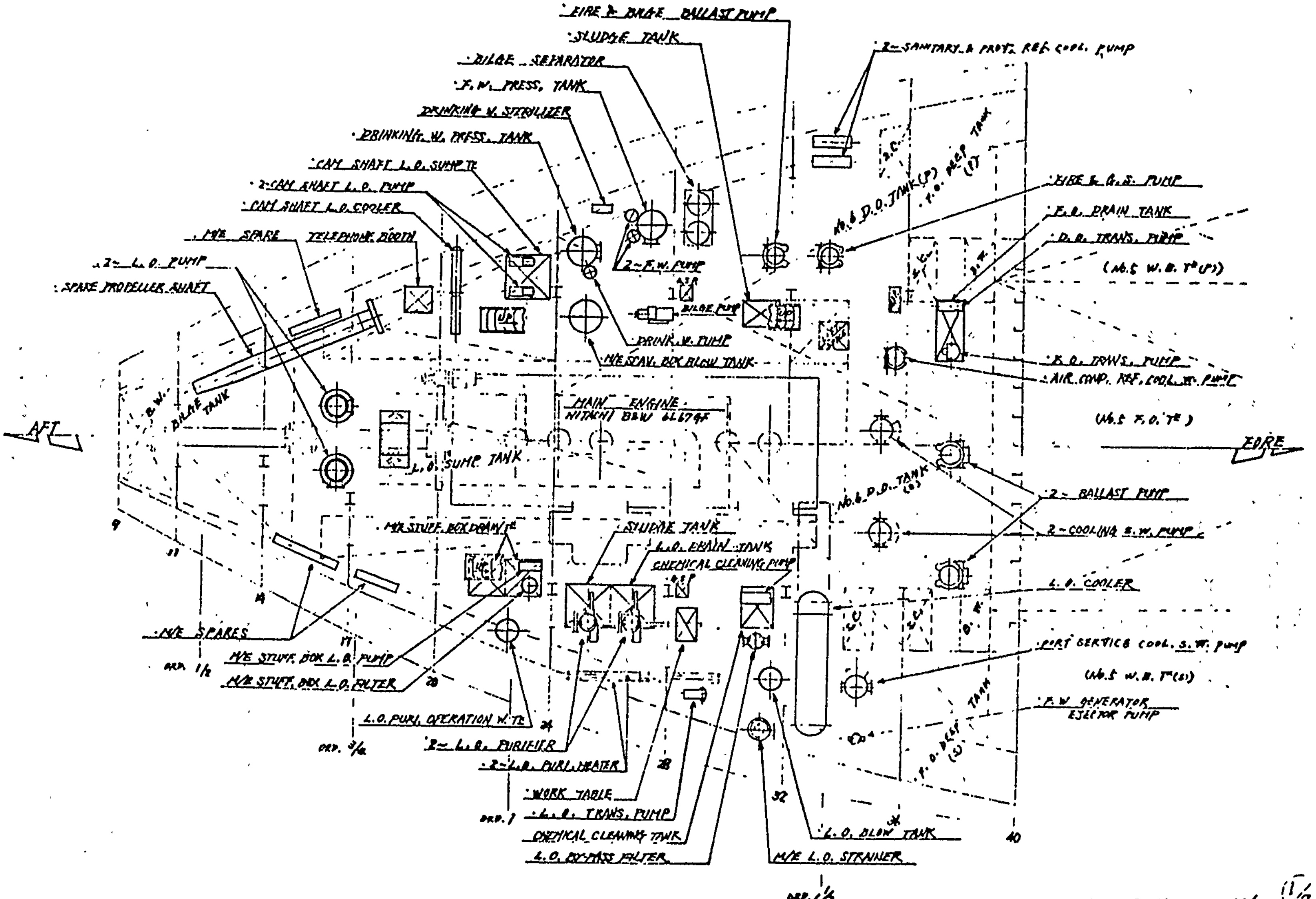
PIPING DESIGN PROCEDURE using HICAS-P
(STEP 1)



HICAS-P PIPING DIAGRAM

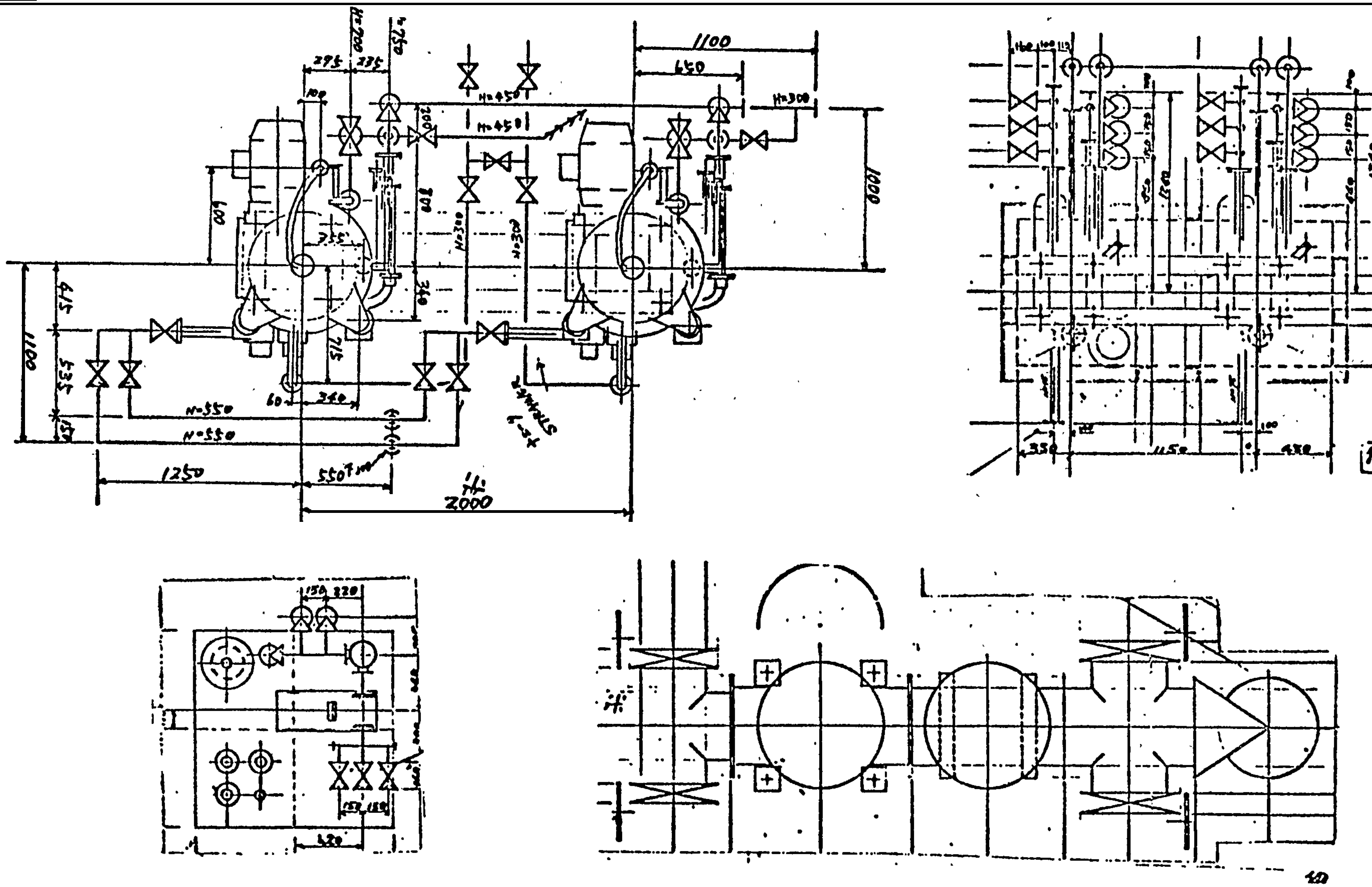


MACHINERY ARRANGEMENT

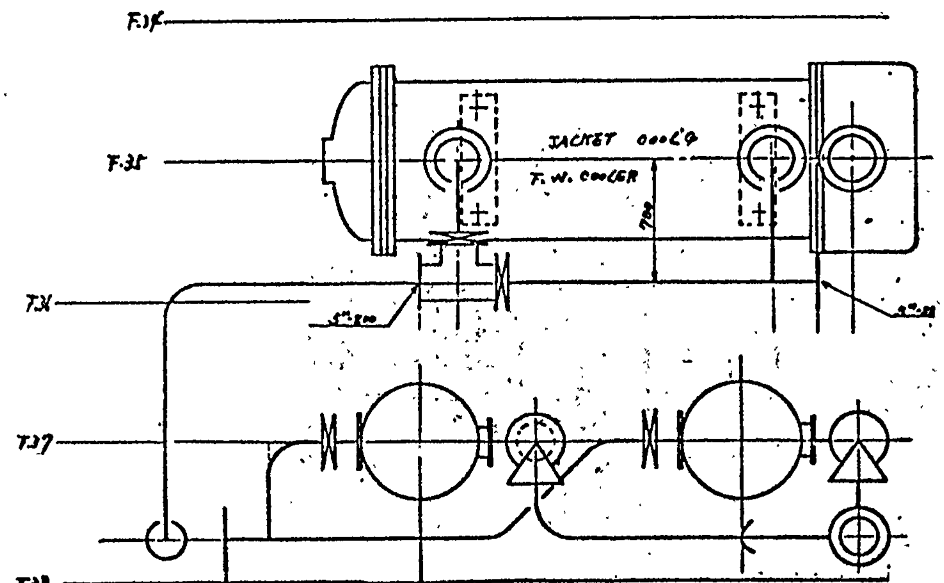


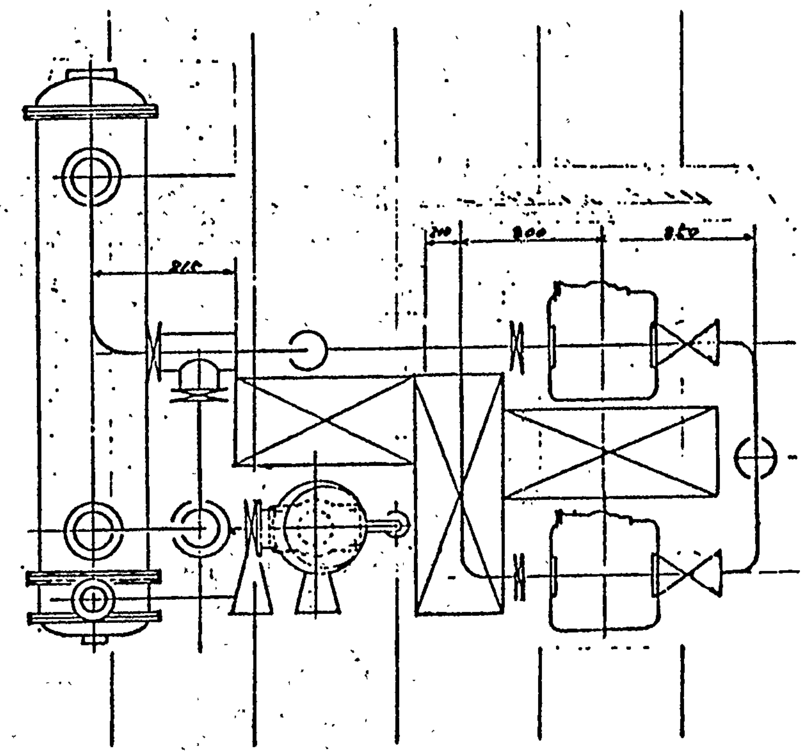
LOWER FLOOR PLAN (1/7)

PIPING UNIT

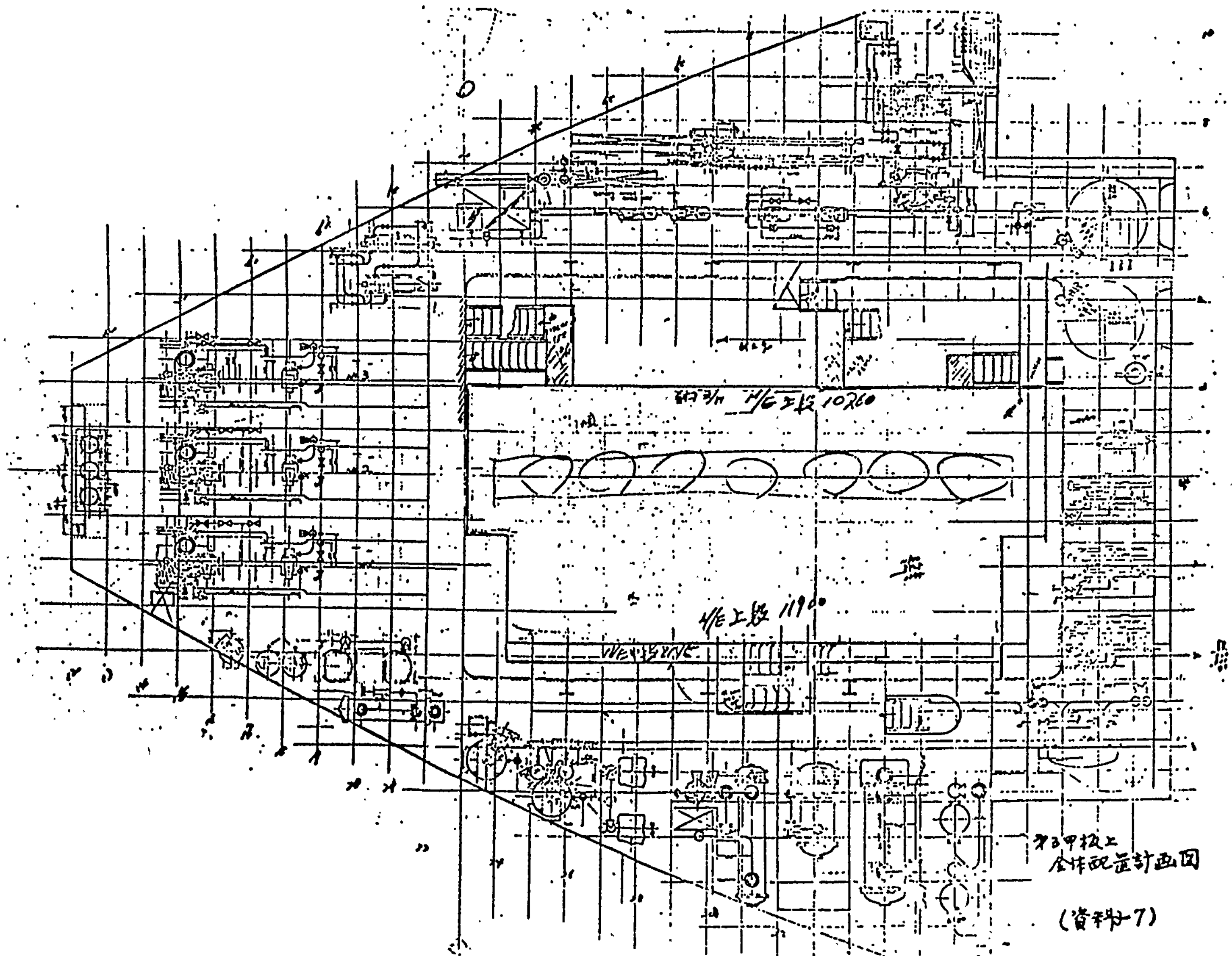


HICAS-P COMPOSITE UNITS



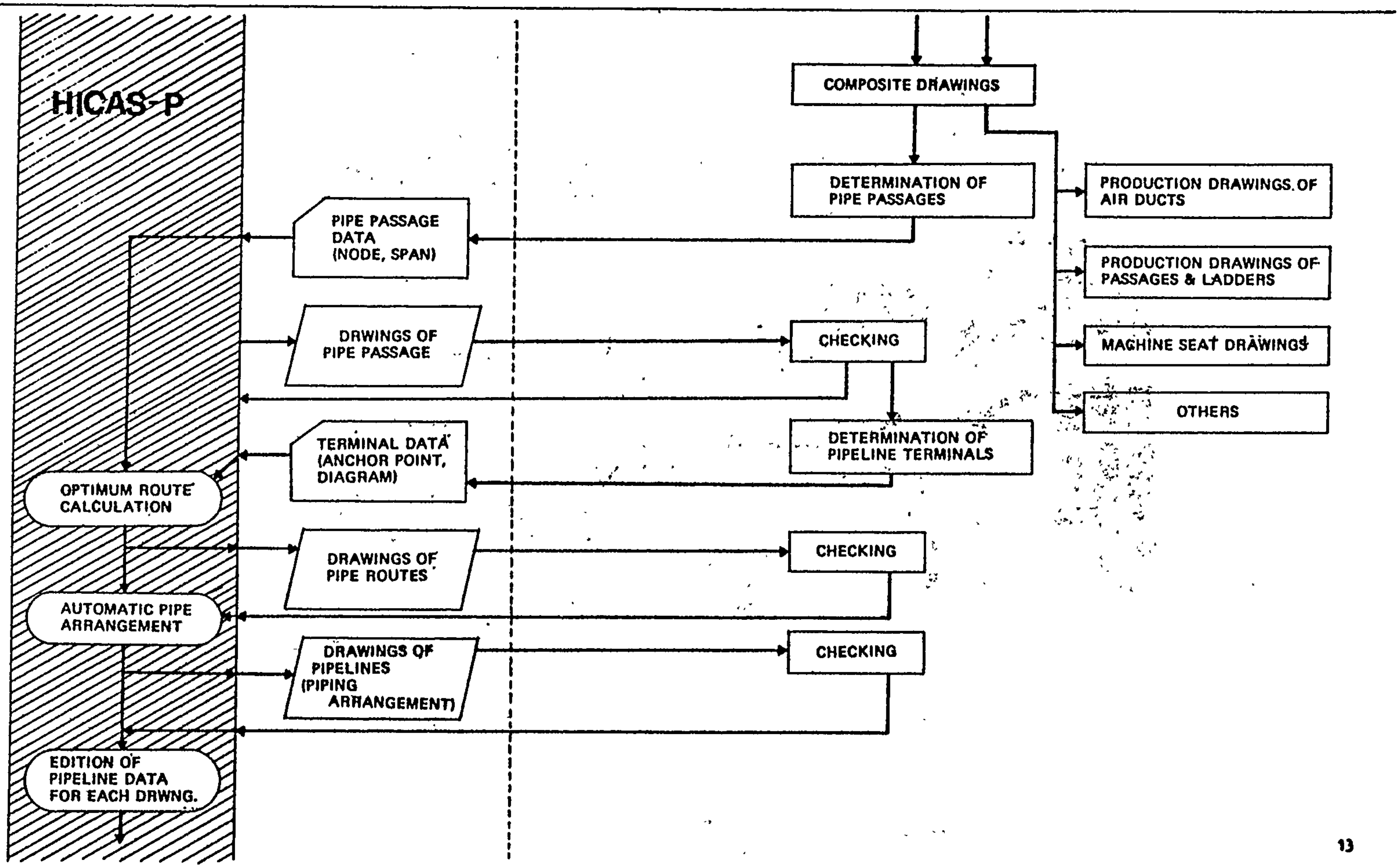


COMPOSITE DRAWING



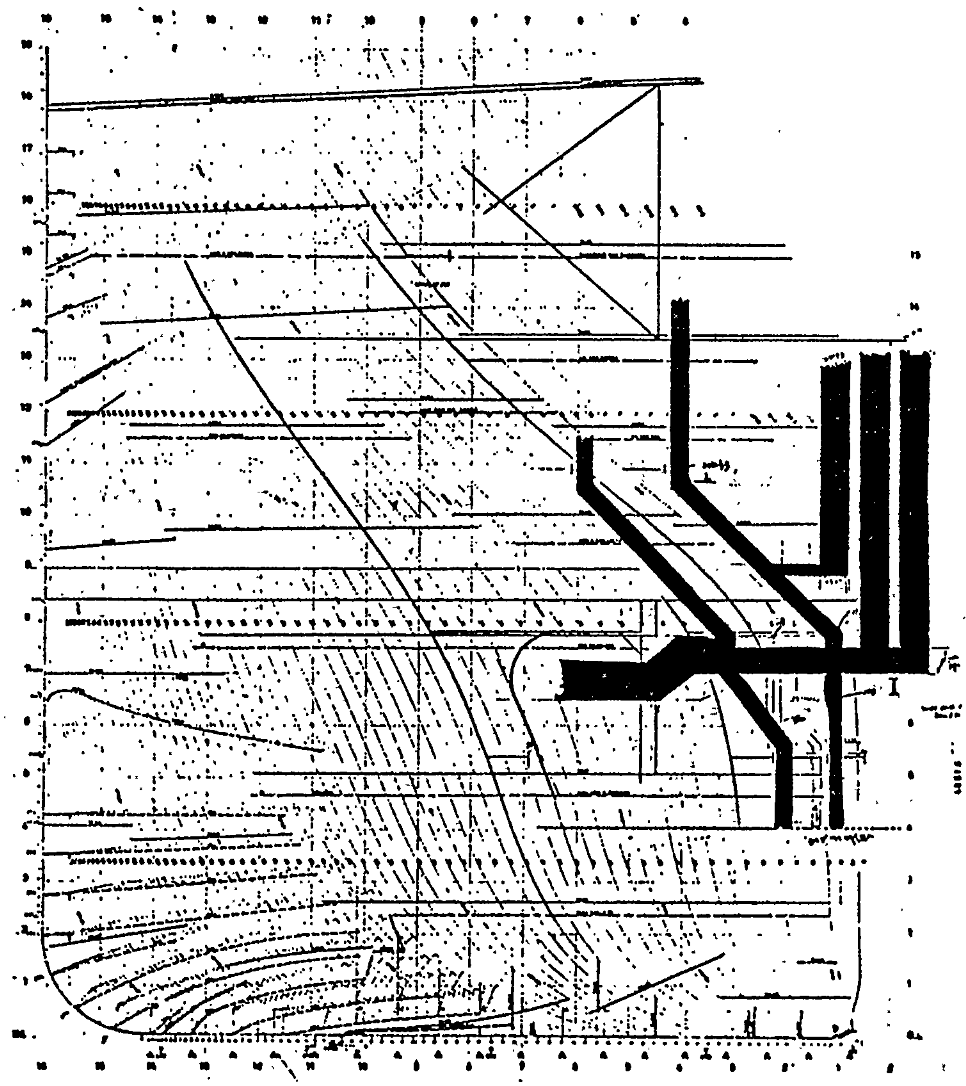
HICAS-P

PIPING DESIGN PROCEDURE using HICAS-P
(STEP 2)

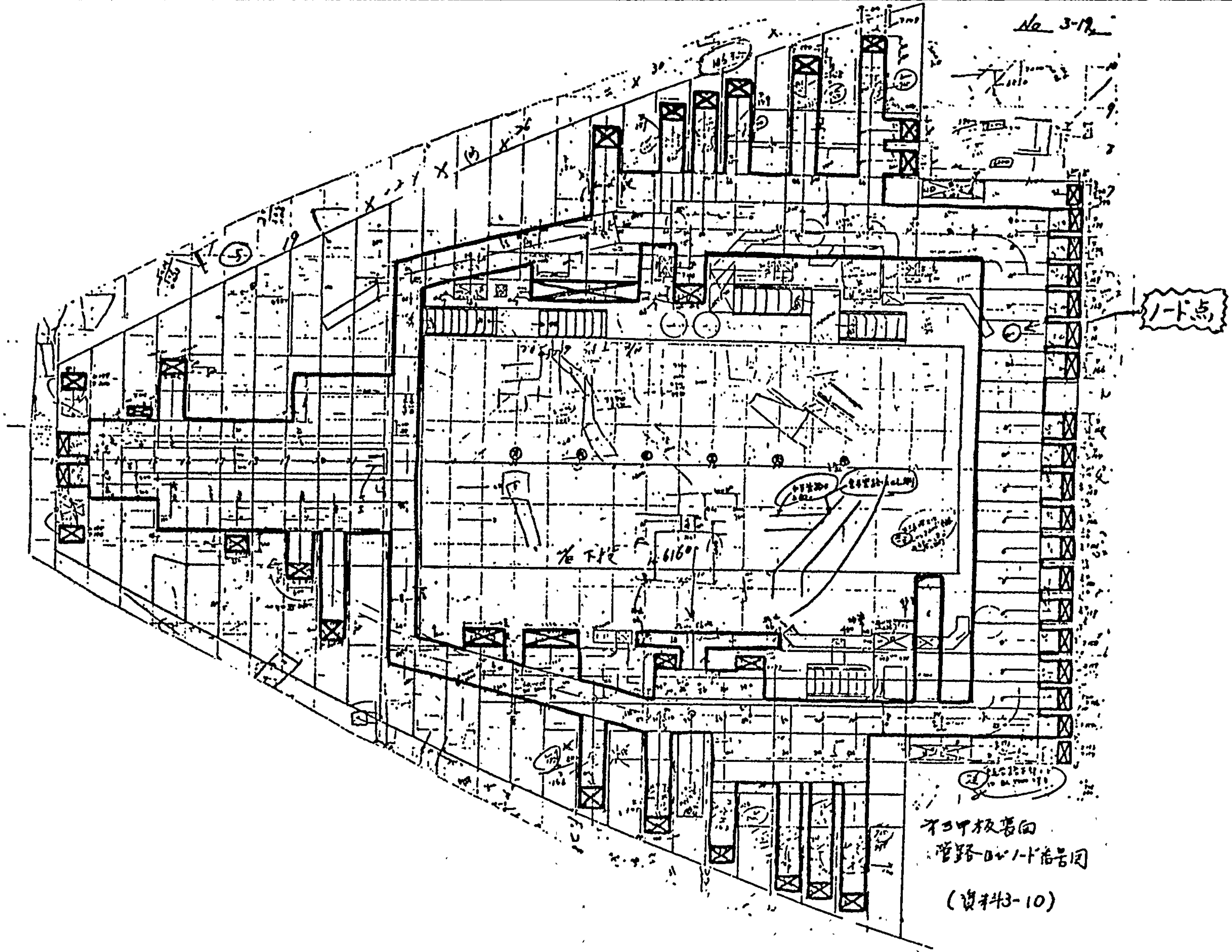


HICAS-P

DETERMINATION OF PIPE PASSAGES
(VERTICAL PASSAGES)

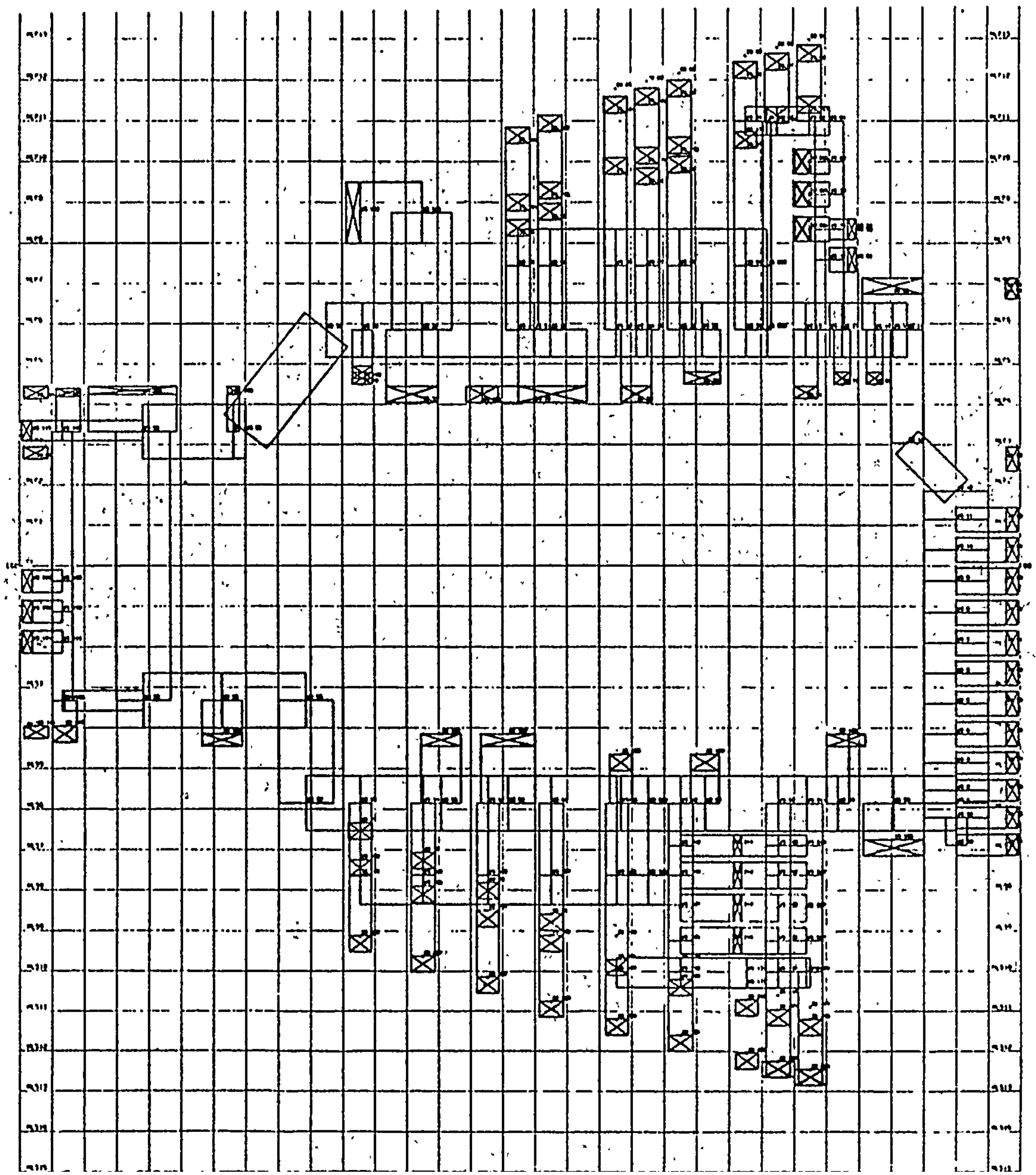


HICAS-P DETERMINATION OF PIPE PASSAGES
(HORIZONTAL PASSAGES)



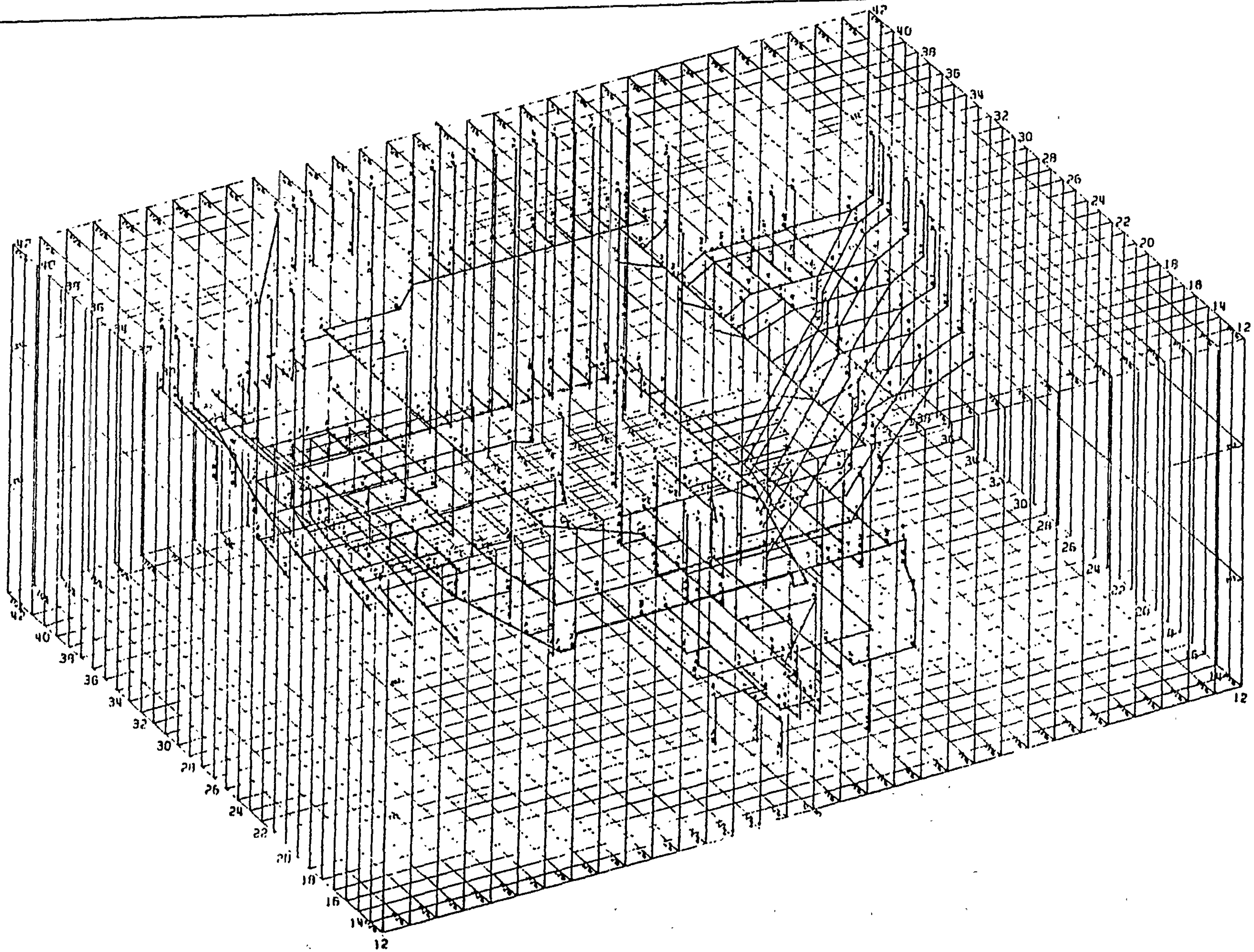
HICAS-P

DRAWING OF PIPE PASSAGES
(PLAN)



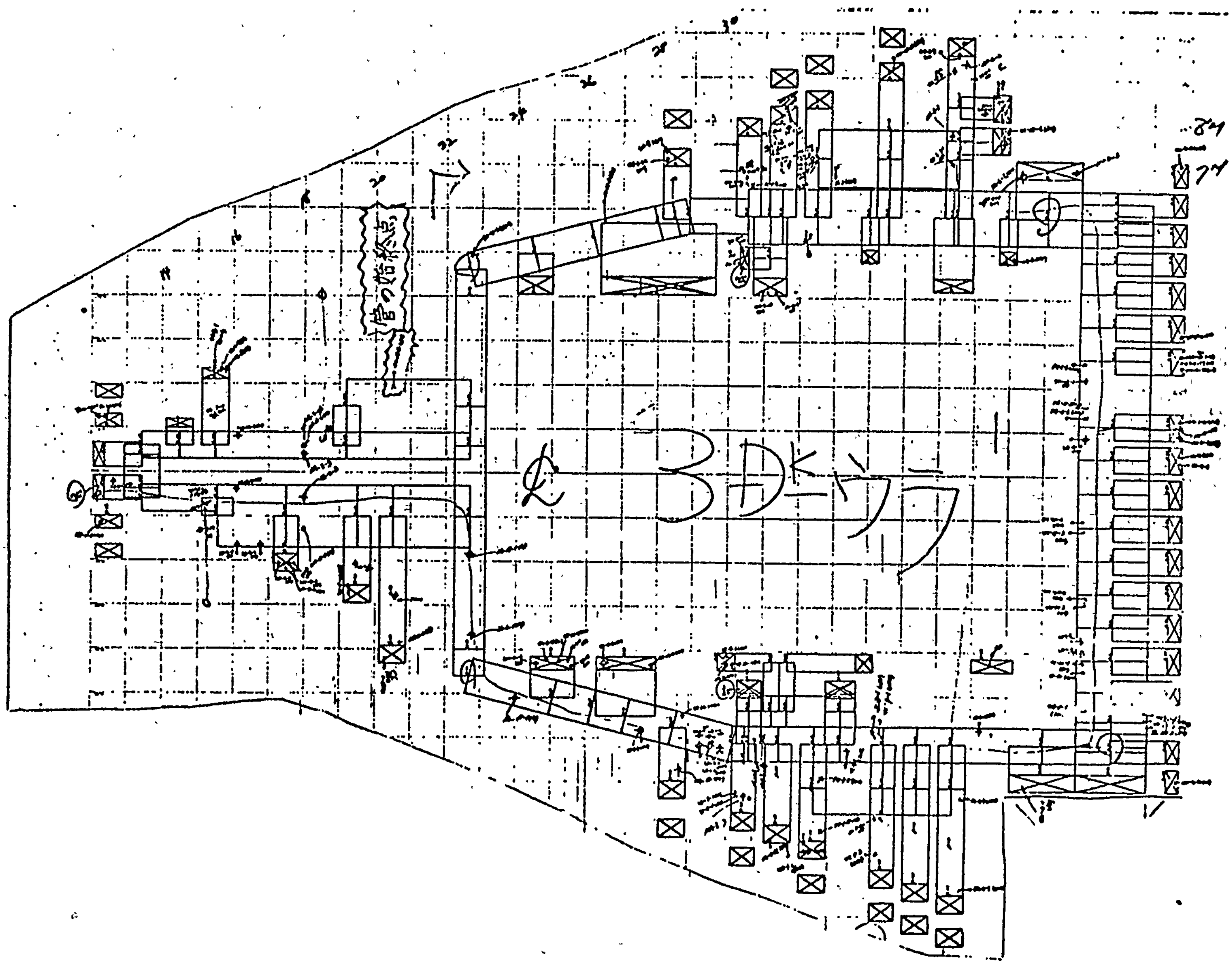
HICAS-P

DRAWING OF PIPE PASSAGES
(ISOMETRIC VIEW)



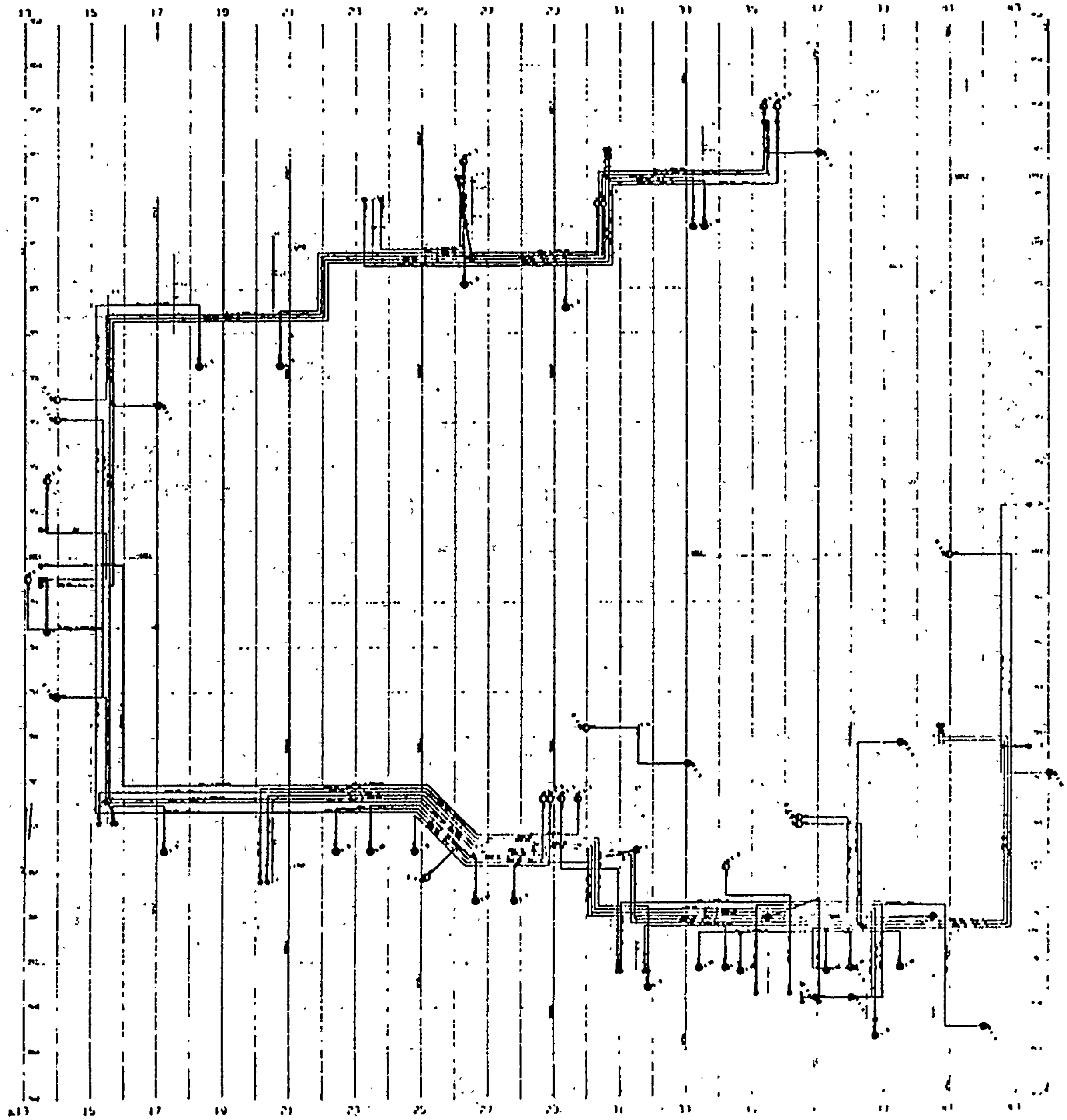
HICAS-P

DETERMINATION OF PIPELINE TERMINALS



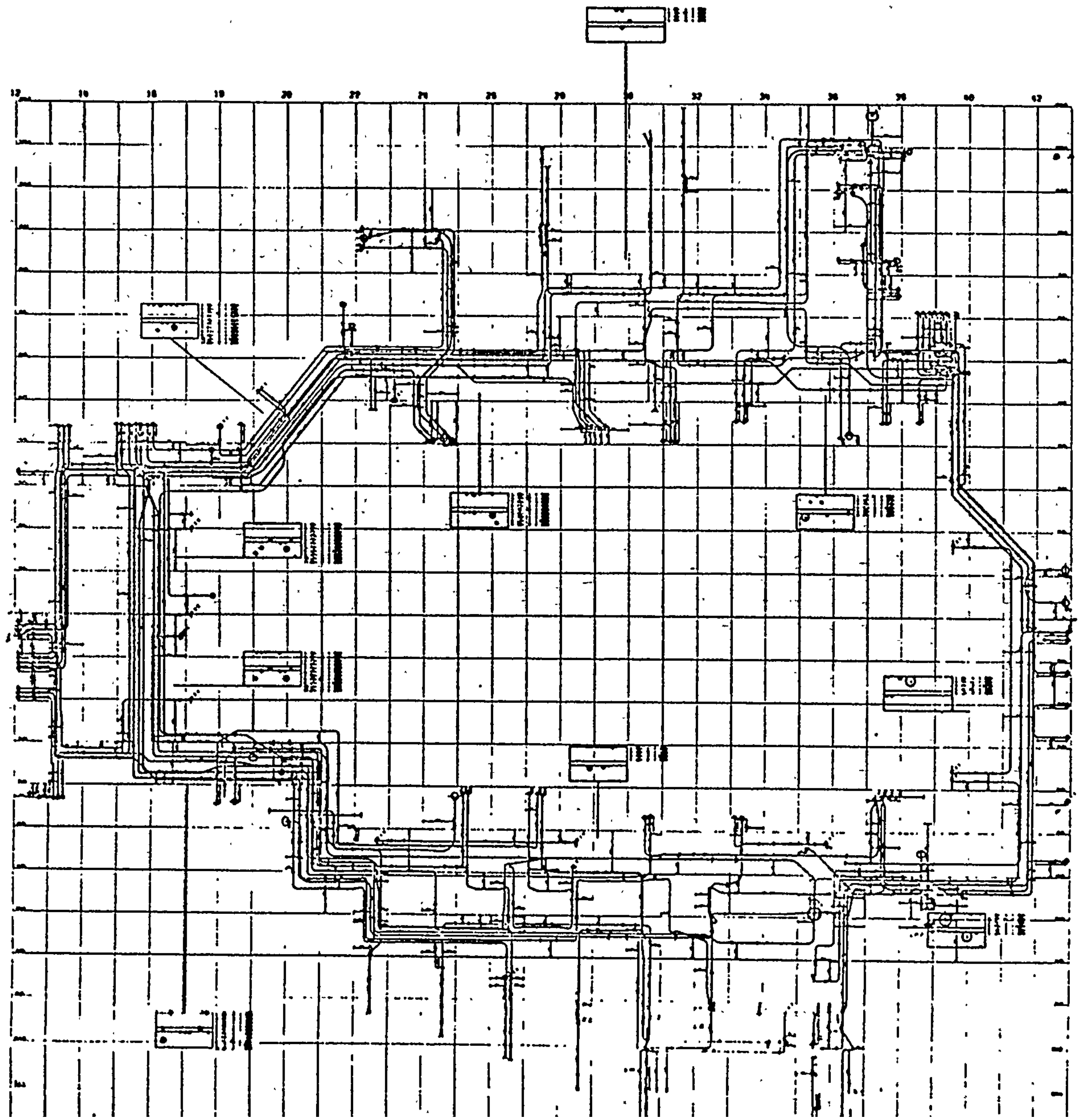
HICAS-P

DRAWING OF PIPE ROUTES



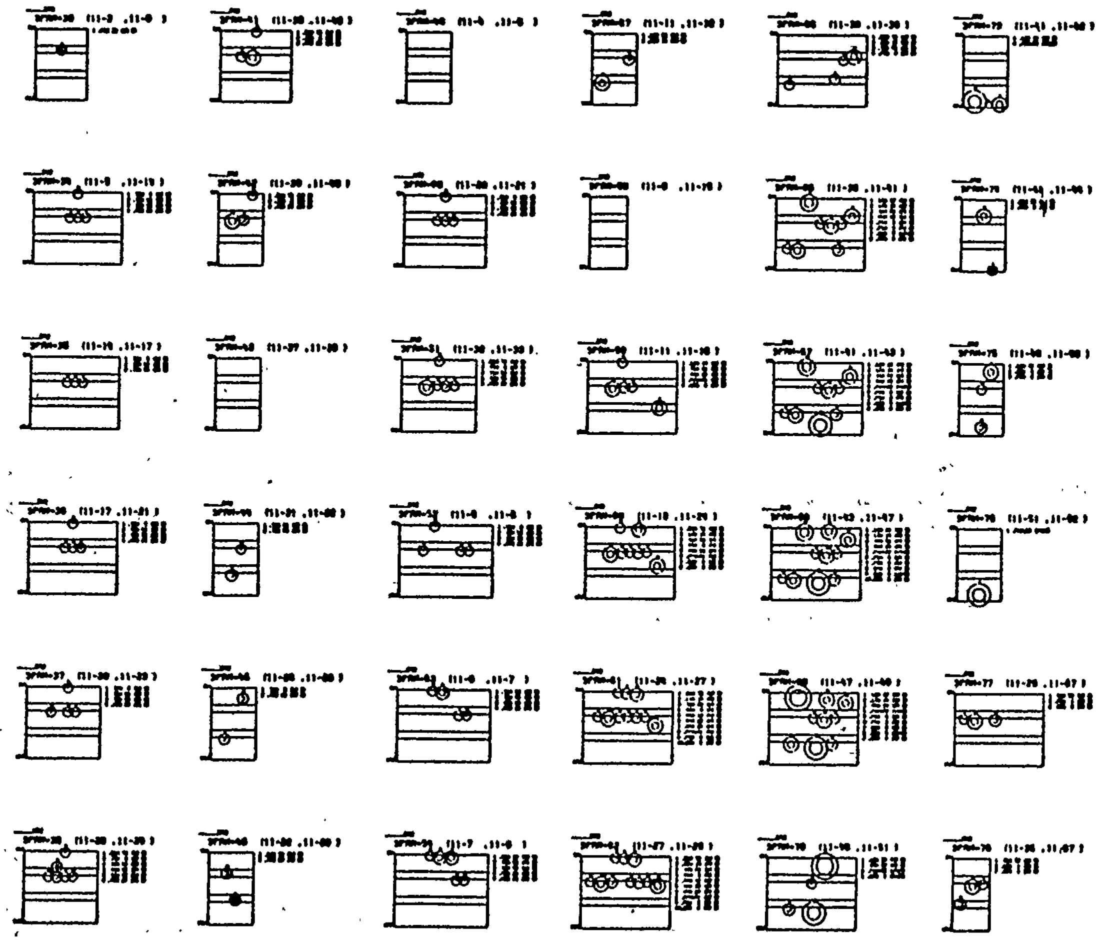
HICAS-P

PIPING ARRANGEMENT



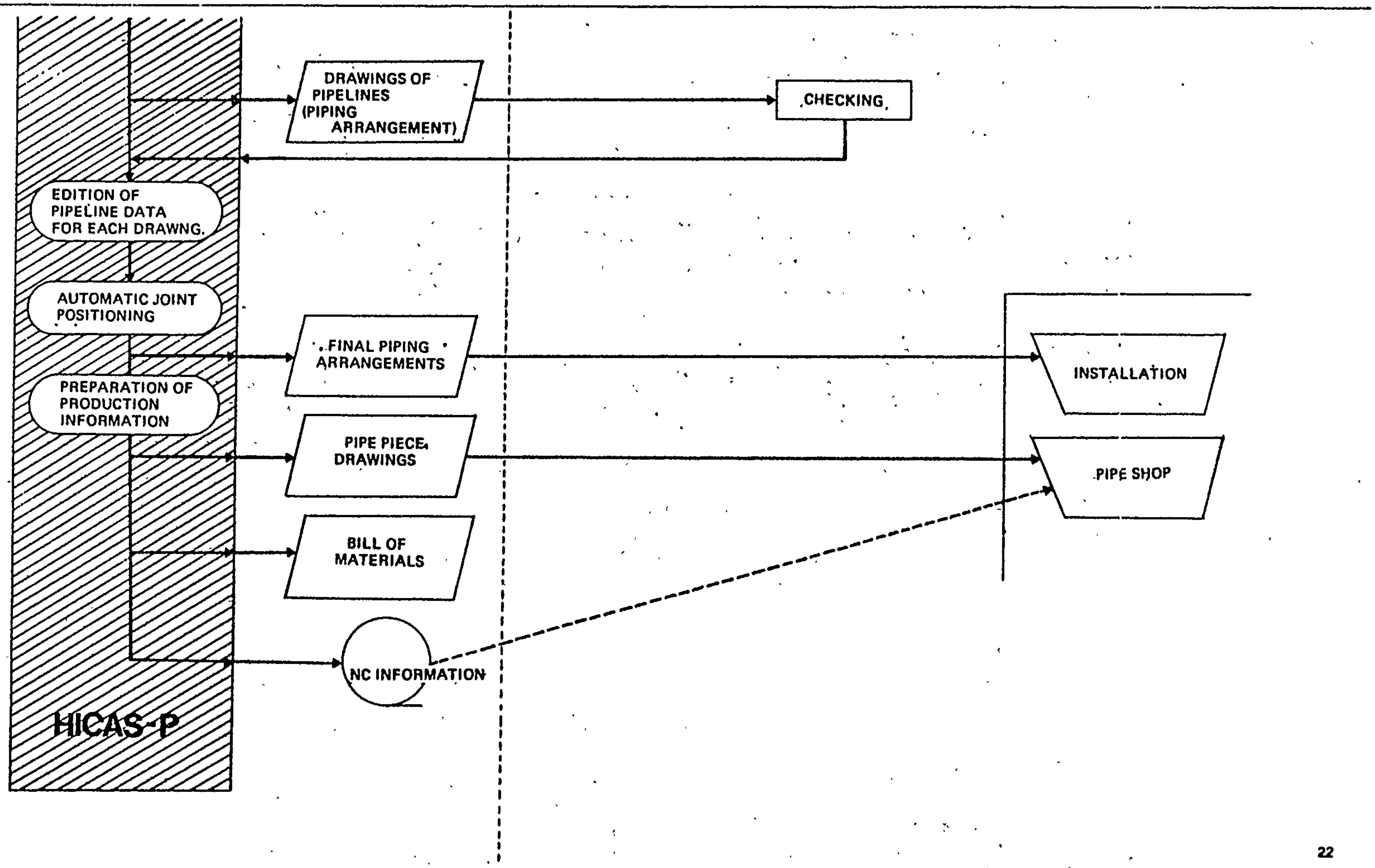
HICAS-P

SECTIONAL DRAWINGS OF PIPE PASSAGES

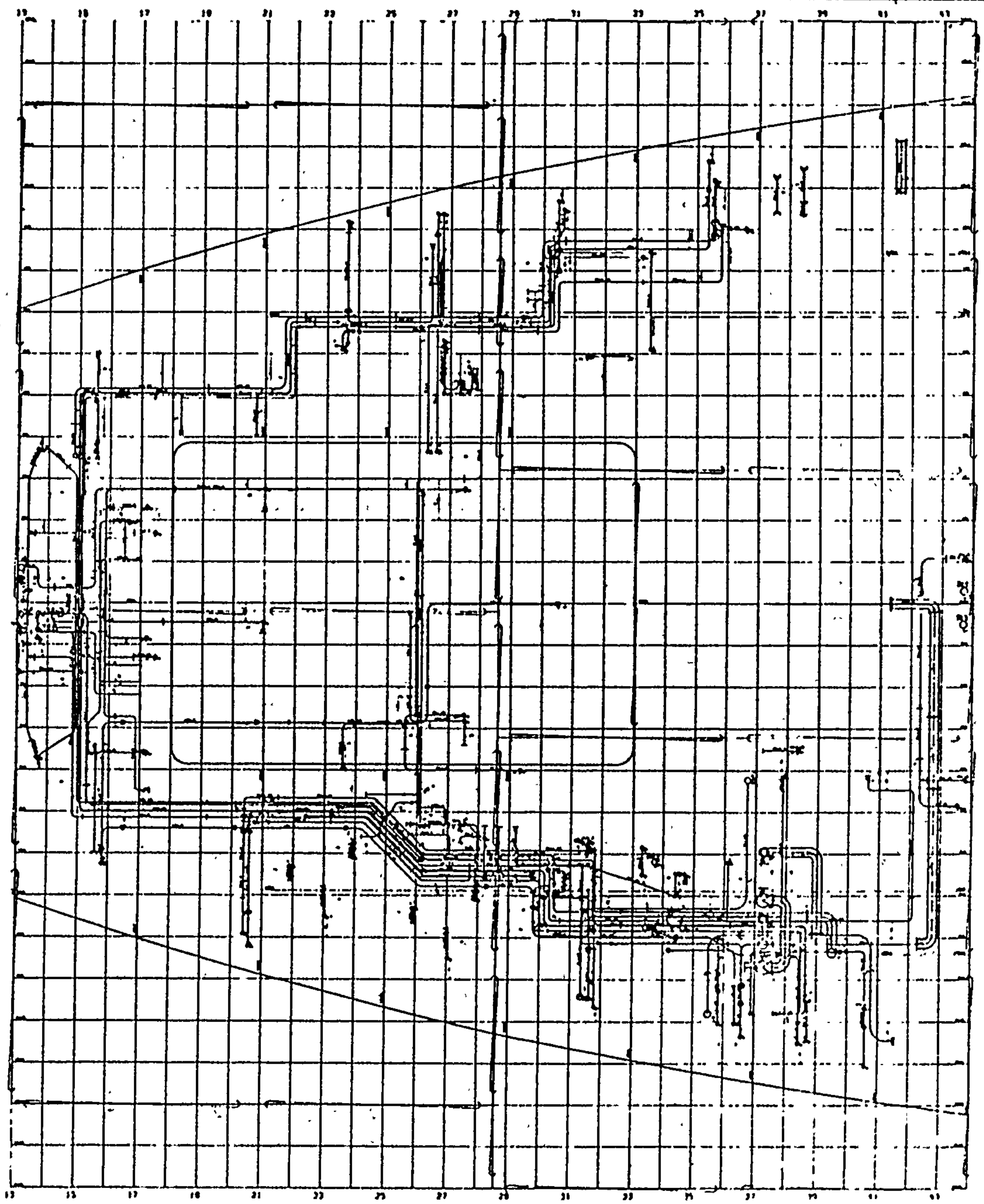


HICAS-P

PIPING DESIGN PROCEDURE using HICAS-P
(STEP 3)



FINAL PIPING ARRANGEMENT



HICAS-P

PIPE PIECE DRAWING

```
S-NO.4484(M)    SHEET NO.77A80321(REV- )    DATE:76/02/21    PAGE:  47:  )
DIV:M32     BLOCK:              UNIT:              S-UNIT:              STAGE:K
----- <PIPE NO.> -----          --------- < TREATMENT TABLE > -------------
PIPE PIECE NO.            NUMBER  PRESS X-RAY PLAT ANNEAL  IN PAT OUT PAT
 AM-  980 -                  1                Z                -       -
```

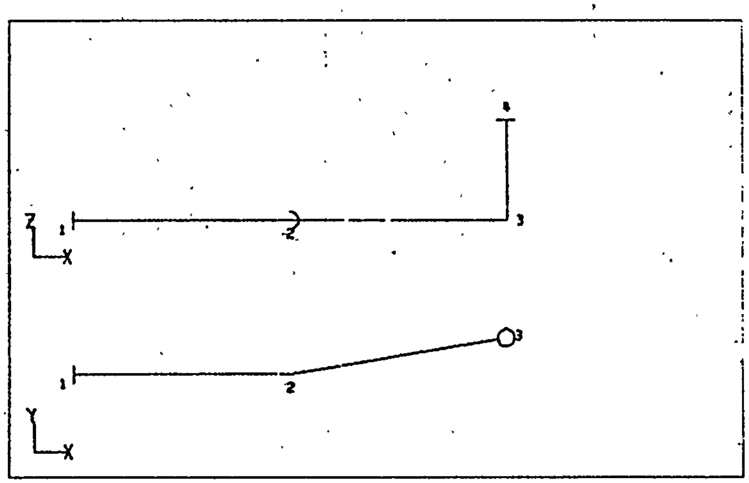
PRODUCTION INFORMATION

```
---------- < MATERIAL TABLE > ------------------- -< MANUFACTURING TABLE >-
POINT  NAME              ADJ. MATERIAL          NUM  CUT.L WELD  FA M.L BRANCH
 1- 4| JGB-    - 25-         |SGP-B                1   1421|          |
    4| F   - 10- 25-         |SS41                 1       | OK  0.0|
    1| F   - 10- 25-         |SS41                 1       | OK  9.5|
```

MATERIAL LIST

```
------------------------- < BENDING INFORMATION > -------------------------
1ST.P L   NC-L    FA     A  :  L  NC-L    RA      A  :  L  NC-L    RA    A
 1  1276( 776)+ 45.0  90.0: 610( 473) -90.0   9.4
```

BENDING INFORMATION



SHAPE OF PIPE PIECE (PROJECTIO

```
--------------------- < MEASUREMENTS OF PIPE PIECE > --------------------
 FM TO|KIND|ANG OTHER| NAME           |   X  |   Y  |   Z  |N| AL&L|MAG.L
   - 1|FL  |         | F  - 10- 25-   |      |      |      | |     |
  1- 2|BR  |  9      |                |  600|       |      | | 600|
  2- 3|BR  | 90      |                |  600|   100|       | | 608|
  3- 4|FL  |         | F  - 10- 25-   |      |      |  278| | 278|
** TOTAL LENGTH: X= 1200 Y=  100 Z=  278 ***** TOTAL WEIGHT:     6KG *****
```

MEASUREMENTS OF PIPE PIECE

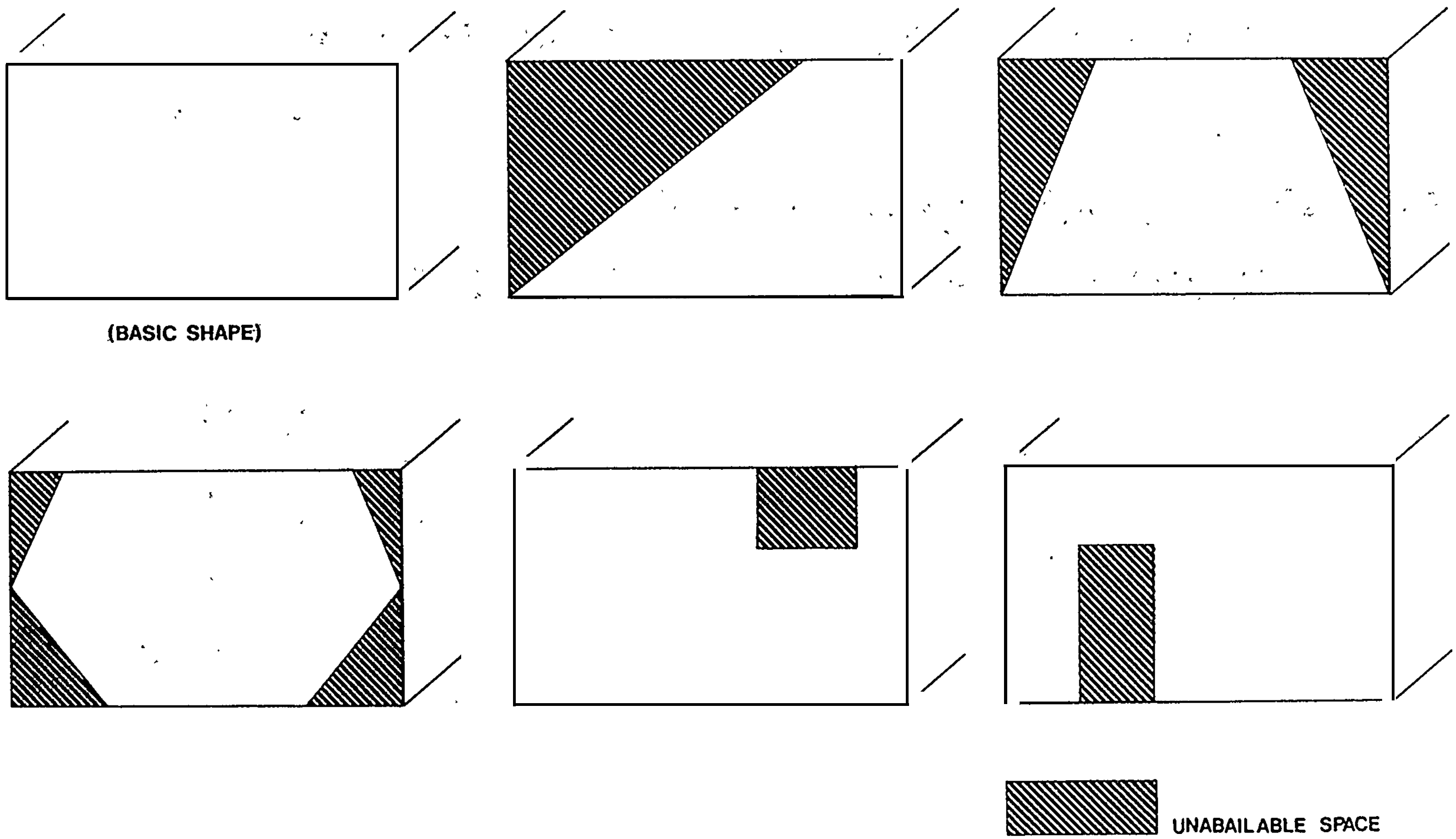
```
M:  /  IC:  /  IB:  /  IF:  /  IN:  /  IG:  /  IS:  /  IE:  /  IH:  /
```

HICAS-P

MAIN FUNCTIONS

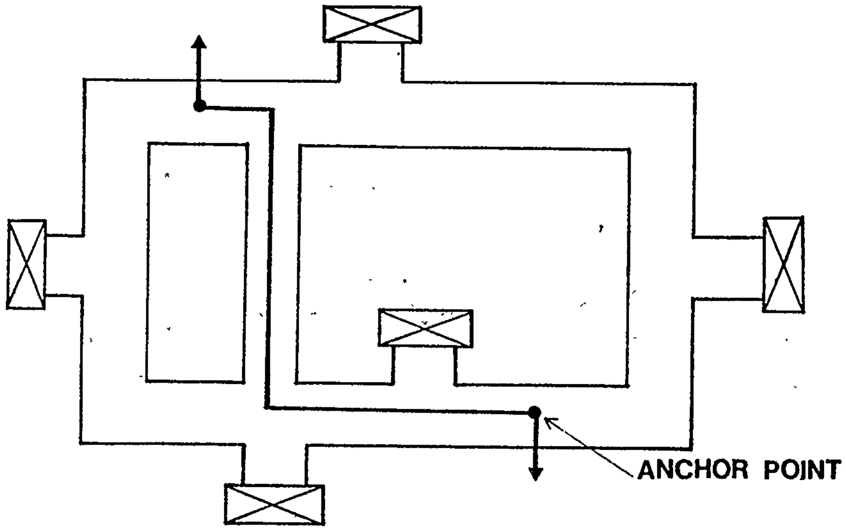
- AUTOMATIC DESIGN FUNCTIONS
- AUTOMATIC DRAWING FUNCTIONS
- CHECKING FUNCTIONS
- FUNCTIONS TO SUPPLY VARIOUS LISTINGS
- FUNCTIONS TO SUPPLY PRODUCTION INFORMATION
- FUNCTIONS TO CONNECT WITH OTHER SYSTEMS
- INTERACTIVE INPUT STATION (PF SYSTEM)

HICAS-P DEFINITION OF PIPE PASSAGE

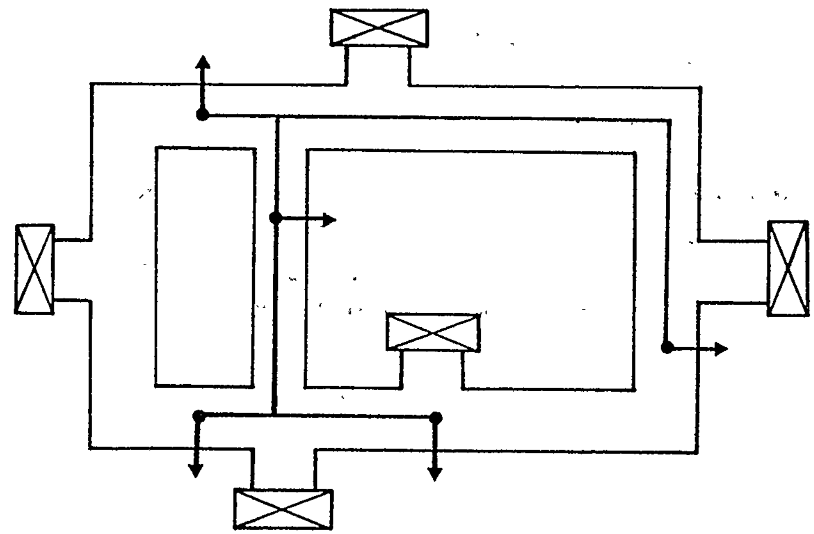


HICAS-P DEFINITION OF PIPING SYSTEM (TERMINALS)

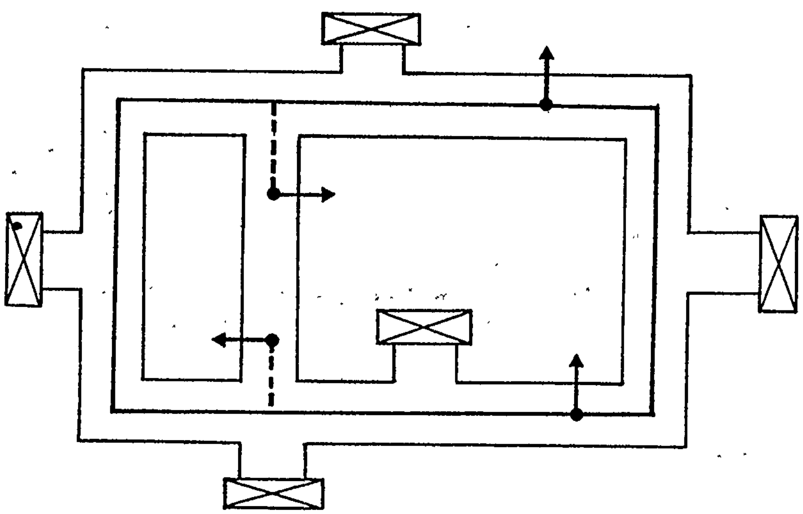
1 ANCHOR POINT—ANCHOR POINT



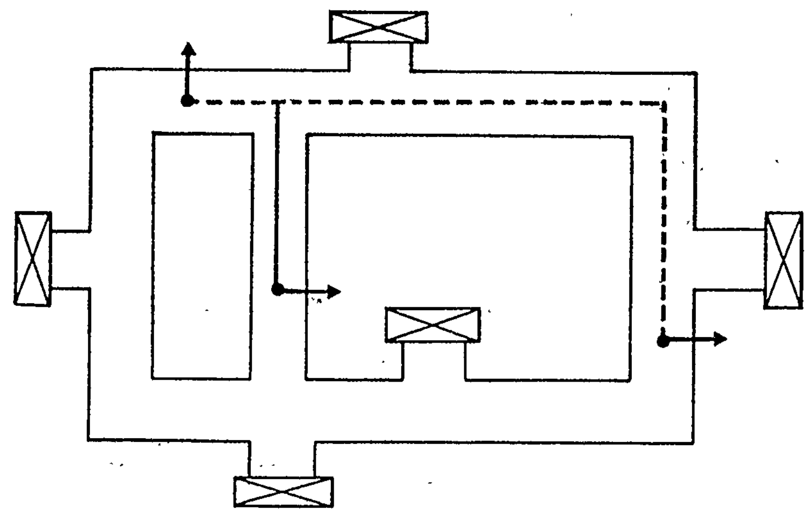
2 GROUPING



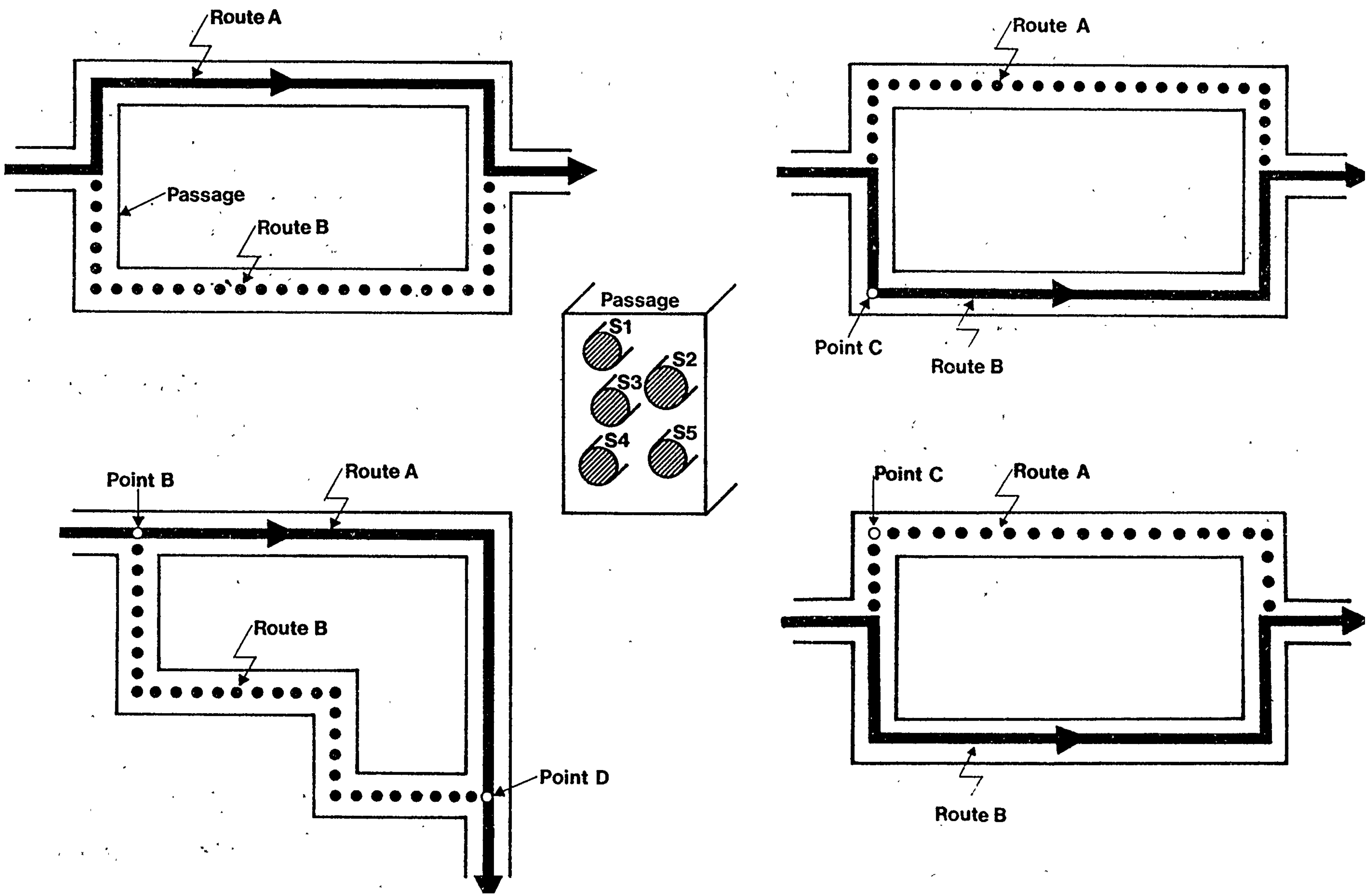
3 RING MAIN



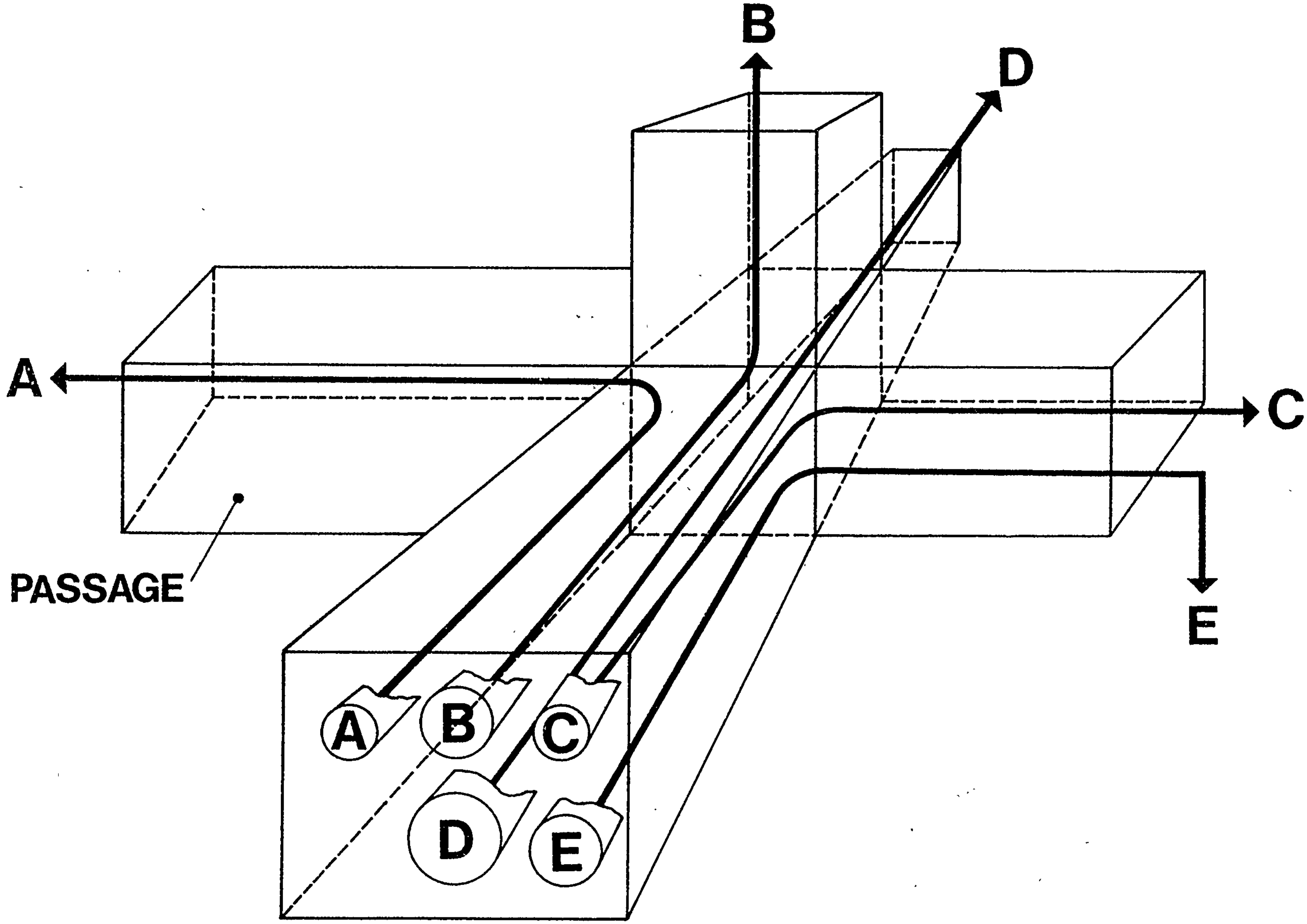
4 ANCHOR POINT—SEQUENCE



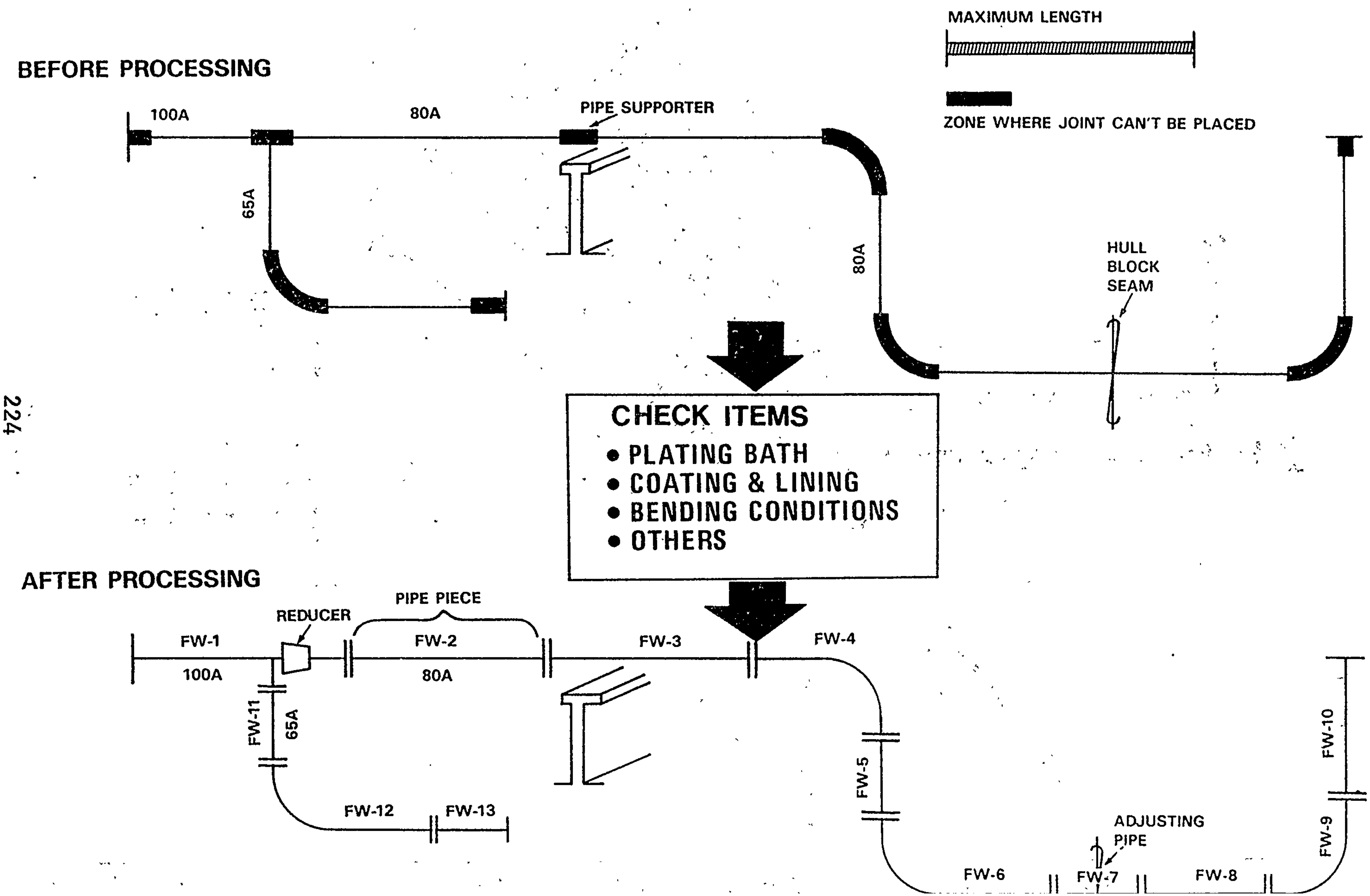
HICAS-P OPTIMUM ROUTE CALCULATION



HICAS-P AUTOMATIC PIPE ARRANGEMENT



HICAS-P AUTOMATIC JOINT POSITIONING



HICAS

AUTOMATIC DRAWING FUNCTION

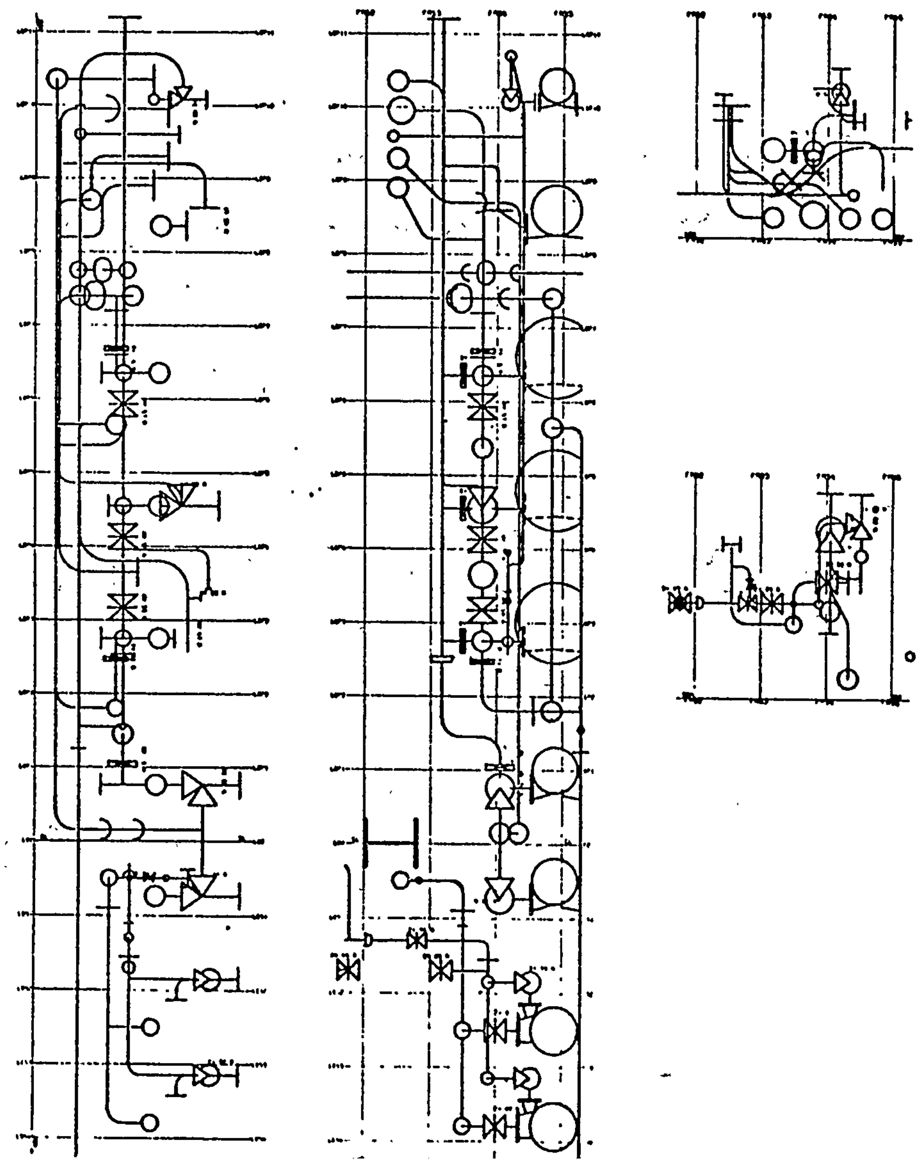
- SPEC. OF THE DRAWING CAN BE FREELY INDICATED

  (VIEW DIRECTION, DRAWING AREA, OBJECT TO BE DRAWN, ETC)

- THE FOLLOWING CAN BE AUTOMATICALLY DRAWN

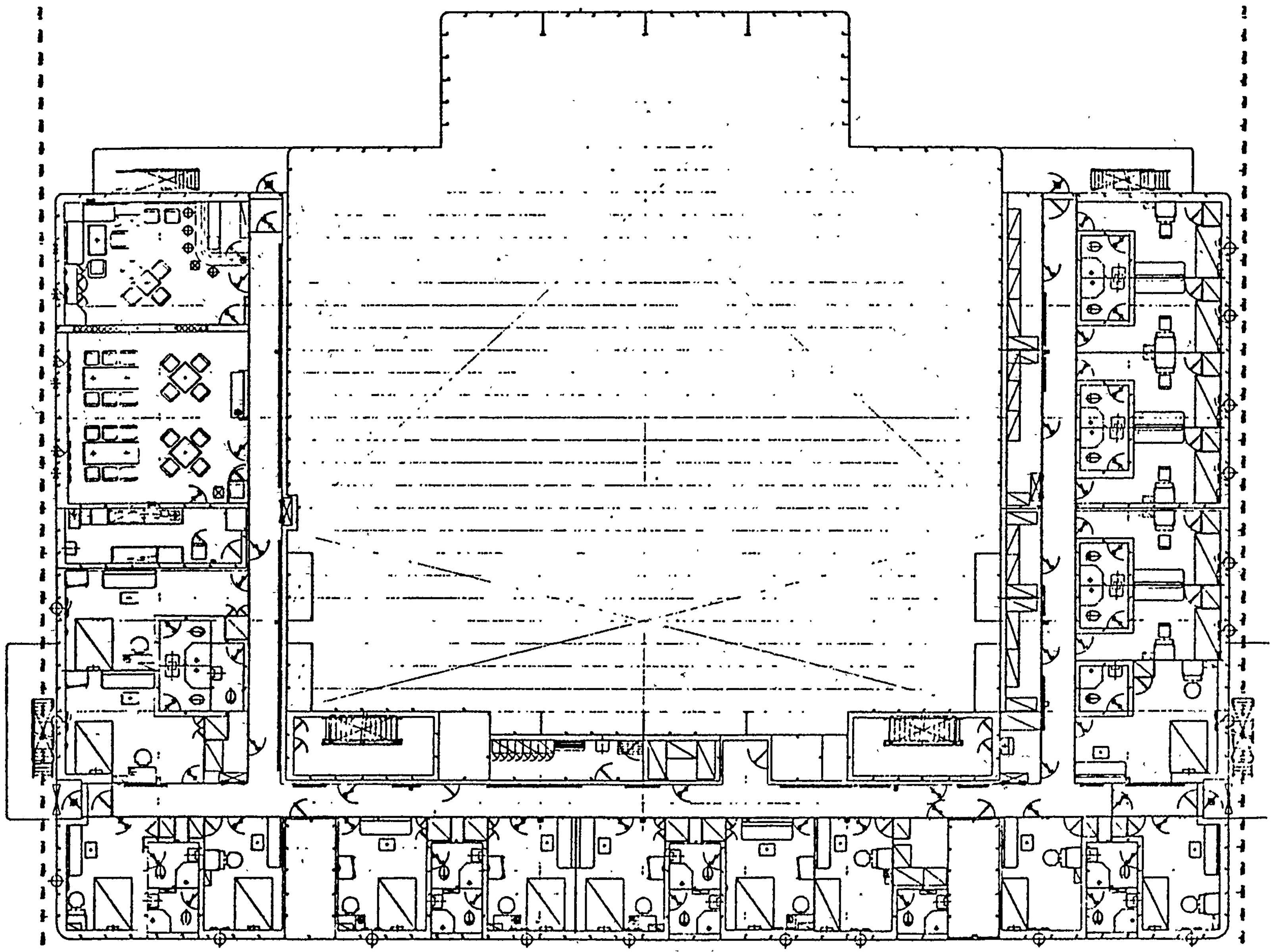
  1. HIDDEN LINE ELIMINATION
  2. RELATIVE POSITION OF PIPELINES FROM HULL STRUCTURE
  3. PIPE PIECE NO., HIGHT OF PIPELINES, DIA. OF PIPES, NAME OF HULL STRUCTURE
  4. OTHERS

AUTOMATIC DRAWING FUNCTION

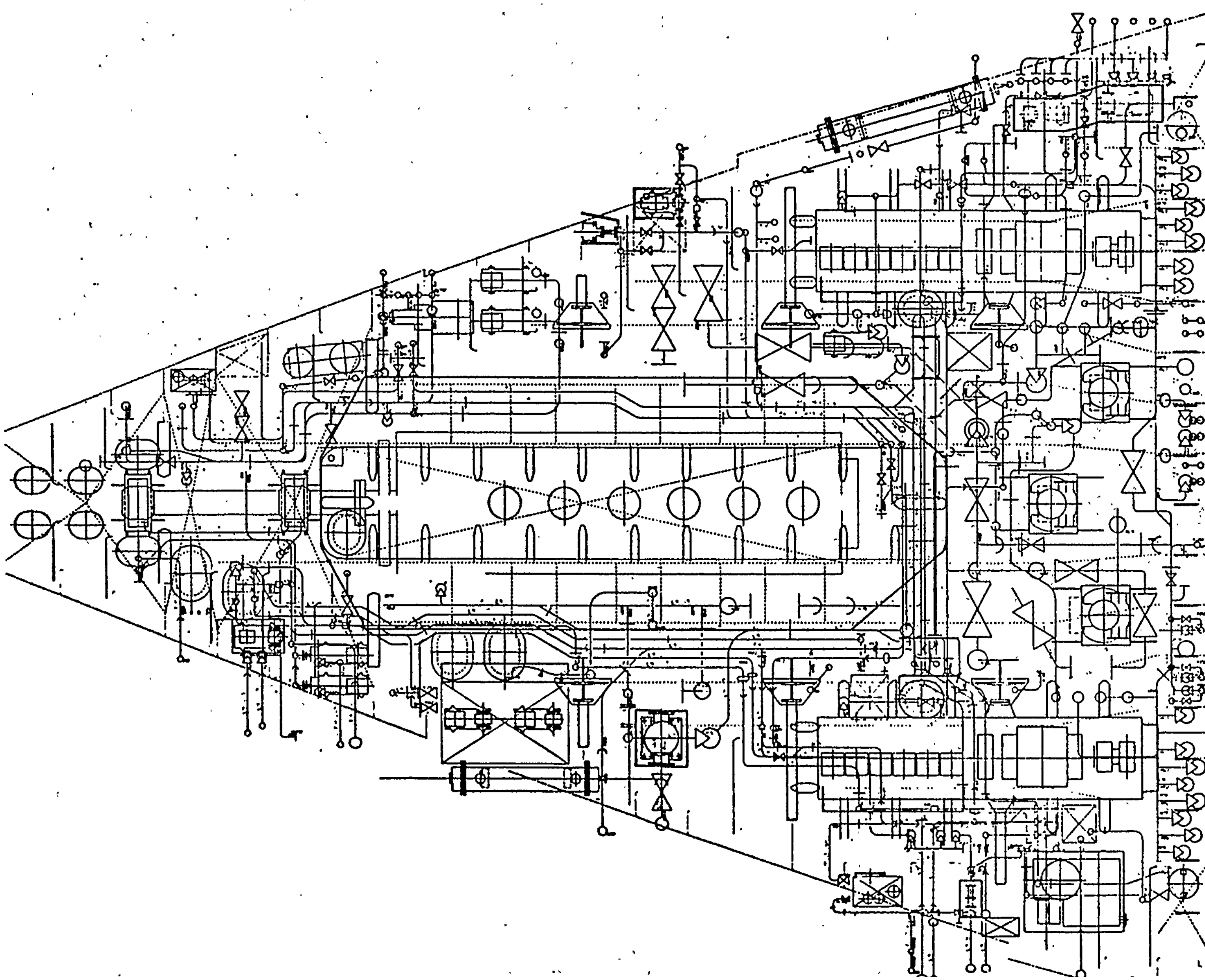


HICAS-P

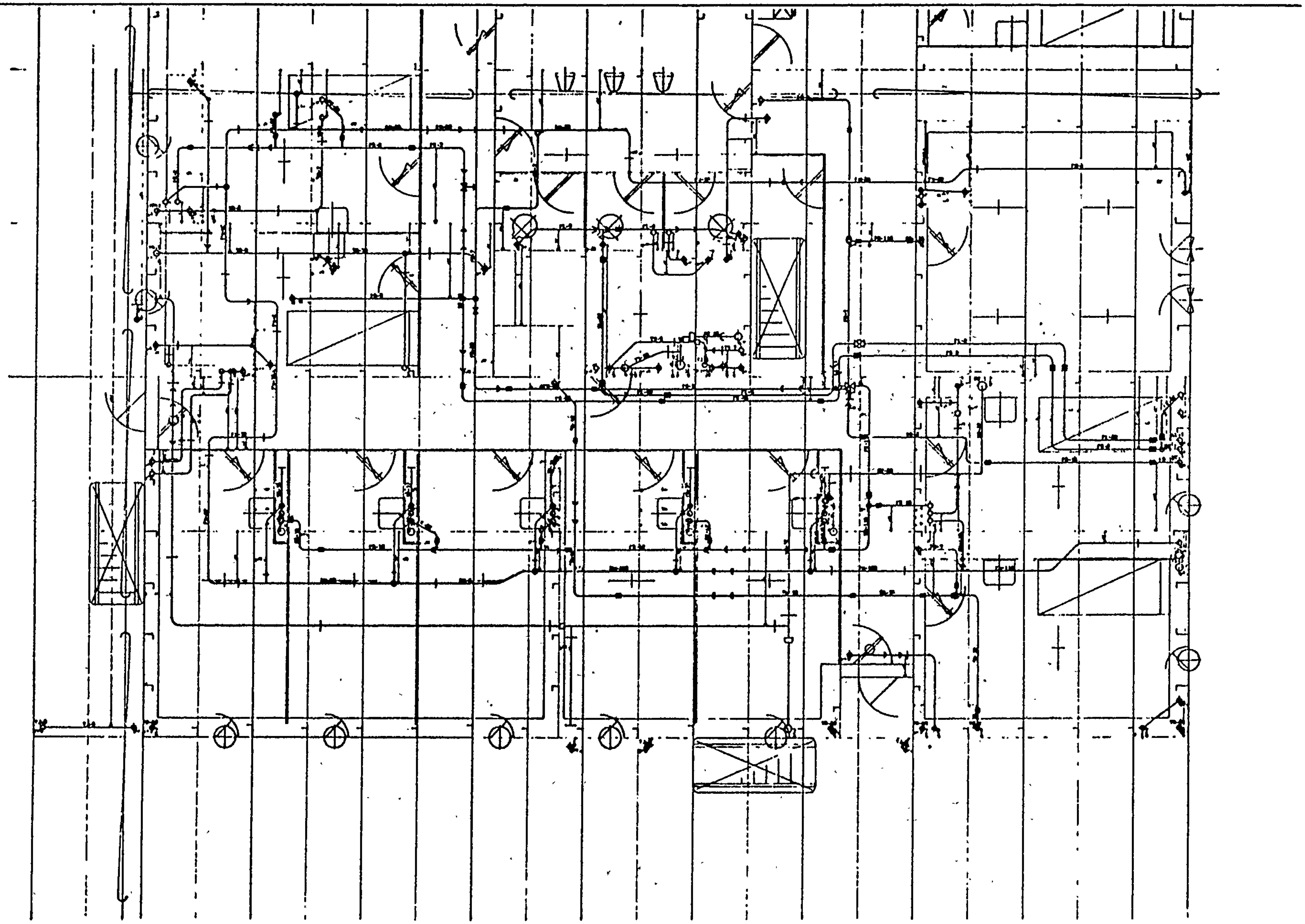
ACCOMMODATION PLAN



PIPING ARRANGEMENT (ENGINE ROOM)

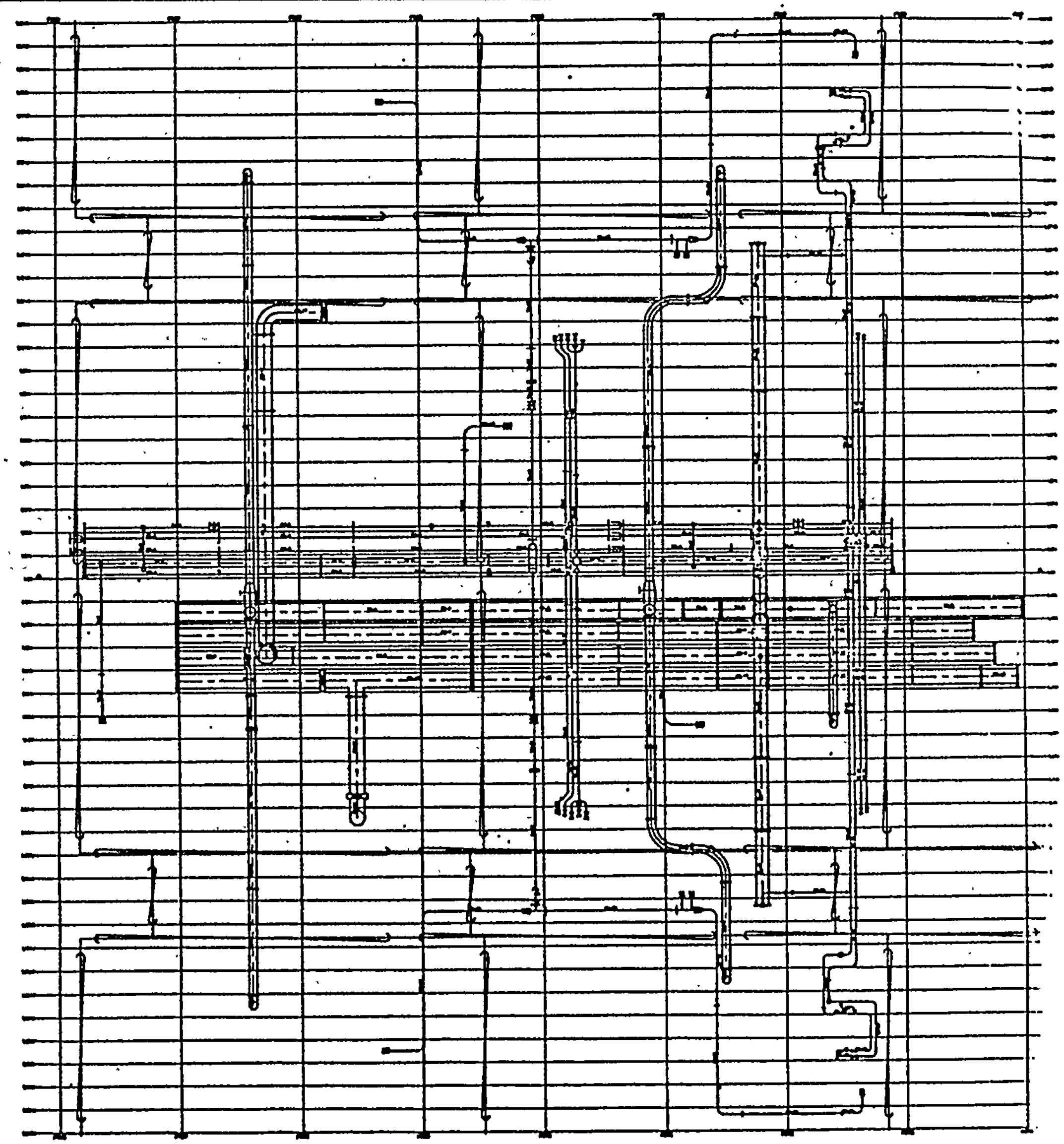


PIPING ARRANGEMENT (ACCOMMODATION)

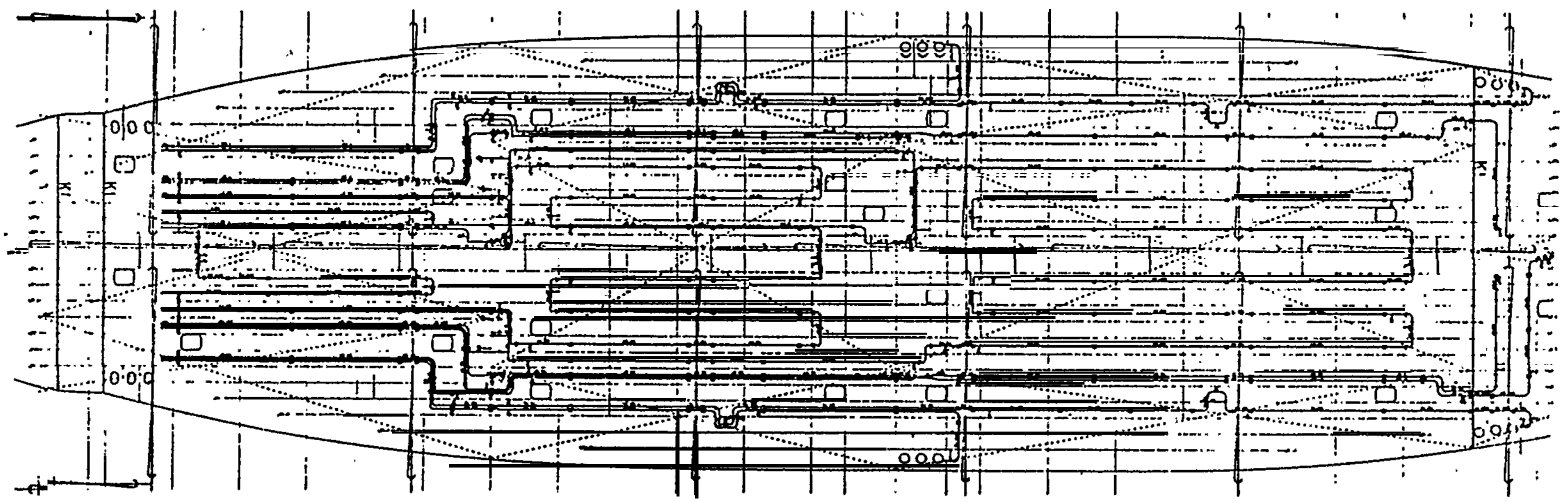


HICAS-P

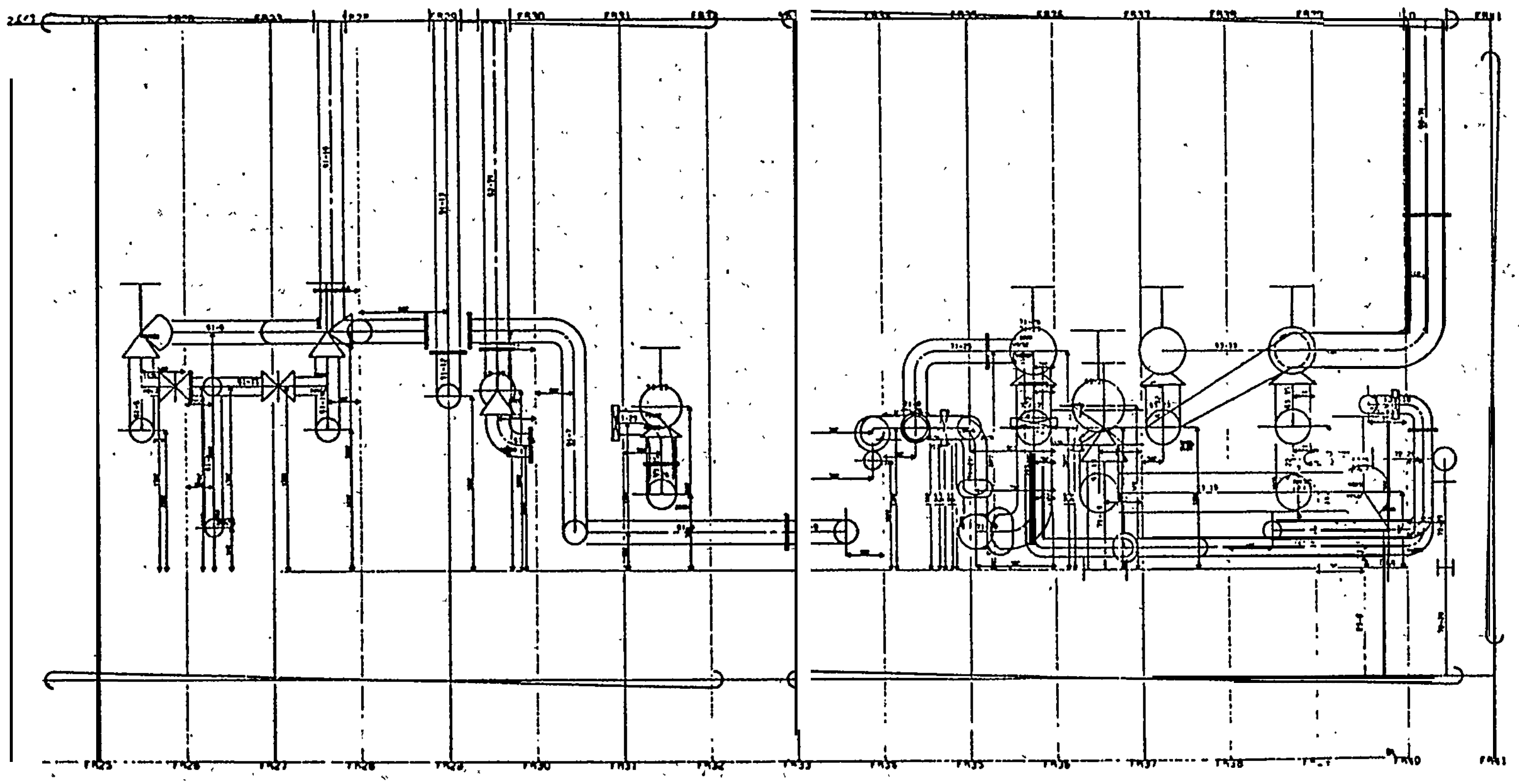
PIPING ARRANGEMENT (ON DECK)



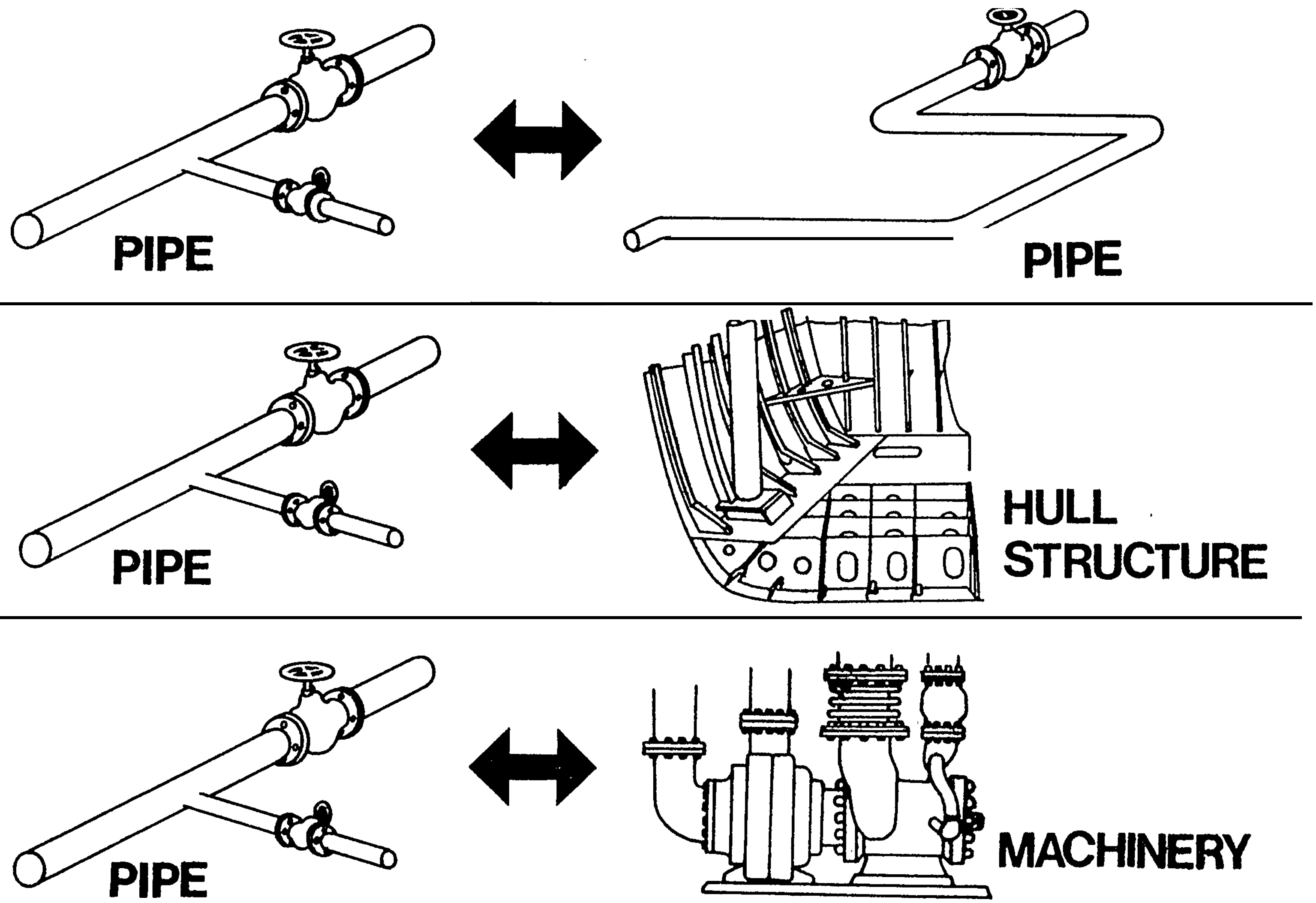
HICAS-P PIPING ARRANGEMENT (IN DOUBLE BOTTOM)



HICAS-P PIPING ARRANGEMENT (ENLARGEMENT, ELEVATION



HICAS-P INTERFERENCE CHECKING FUNCTION



HICAS-P INTERFERENCE CHECK LIST

```
-------------- HICAS-P   INTERFERENCE   CHECK LIST -------------

** S.NO=4484, SHOP=MA, SHEET NO=77AM6-04, DESIGNER=                              ** DATE 76/01/29        PAGE   9 **

NO. 33  PIPE TO PIPE (P.NO=    3, P.NO= 163, L.NAME=LI 2   , SEQ=   7) TO (P.NO= 166, P.NO= 167, L.NAME=LI 2   , SEQ=   8)

                 A-F:FR28 F    414              A-F:FR28 F    414              A-F:FR26 F    400              A-F:FR28 F    400
        P.NO=  3 P-S:LGS5 P    127   P.NO= 163  P-S:LGS5 P    127   P.NO= 166  P-S:LGS5 P    120   P.NO= 167  P-S:LGS5 P    120
                 U-D:DBM  U    357              U-D:DBM  U    507              U-D:DBM  U   1380              U-D:DBM  U    507

                 *****************       INTERFERENCE DEPTH=    45      *****************

NO. 34  PIPE TO JOINT ( P.NO=    9, P.NO= 233, L.NAME=LI 2   , SEQ=  13) TO (P.NO= 170, L.NAME=LI 2   , SEQ=   9, JOINT NAME=  FL

                 A-F:FR35 A    209              A-F:FR36 A    219              A-F:FR36 A     74
        P.NO=  9 P-S:LGS8 P     90   P.NO= 233  P-S:LGS8 S    306   P.NO= 170  P-S:LGS8 S     28
                 U-D:DBM  U    317              U-D:DBM  U    317              U-D:DBM  U    330

                 *****************       INTERFERENCE DEPTH=    90      *****************

NO. 35  PIPE TO PIPE (P.NO= 171, P.NO= 172, L.NAME=LI 2   , SEQ=   9) TO (P.NO= 184, P.NO= 185, L.NAME=LI 2   , SEQ= 10)

                 A-F:FR33 A    116              A-F:FR31 F    269              A-F:FR33 A    120              A-F:FR31 A     41
        P.NO= 171 P-S:LGS7 P   190   P.NO= 172  P-S:LGS6 S    169   P.NO= 184  P-S:LGS7 P     20   P.NO= 185  P-S:LGS6 S    215
                 U-D:DBM  U    330              U-D:DBM  U    330              U-D:DBM  U    324              U-D:DBM  U    324

                 *****************       INTERFERENCE DEPTH=    43      *****************

NO. 36  PIPE TO PIPE (P.NO= 171, P.NO= 172, L.NAME=LI 2   , SEQ=   9) TO (P.NO= 103, P.NO= 104, L.NAME=LI 3   , SEQ=   2)

                 A-F:FR33 A    116              A-F:FR31 F    [illegible]      A-F:FR36 A    175              A-F:FR32 A    226
        P.NO= 171 P-S:LGS7 P   190   P.NO= 172  P-S:LGS6 S    [illegible]   P.NO= 103  P-S:LGS8 S    453   P.NO= 104  P-S:LGS7 P    173
                 U-D:DBM  U    330              U-D:DBM  U    330              U-D:DBM  U    324              U-D:DBM  U    324

                 *****************       INTERFERENCE DEPTH=    44      *****************
```

HICAS-P PIPE PIECE DRAWING

```
S-NO.4484(M)    SHEET NO.77A80321(REV- )    DATE:76/02/21    PAGE:  47:  :
DIY:M32     BLOCK:              UNIT:                S-UNIT:             STAGE:K
----- <PIPE NO.> -----       --------- < TREATMENT TABLE > --------------
PIPE PIECE NO.          NUMBER  PRESS X-RAY PLAT ANNEAL  IN PAT OUT PAT
 AM-   980 -               1                  2                -     -
```

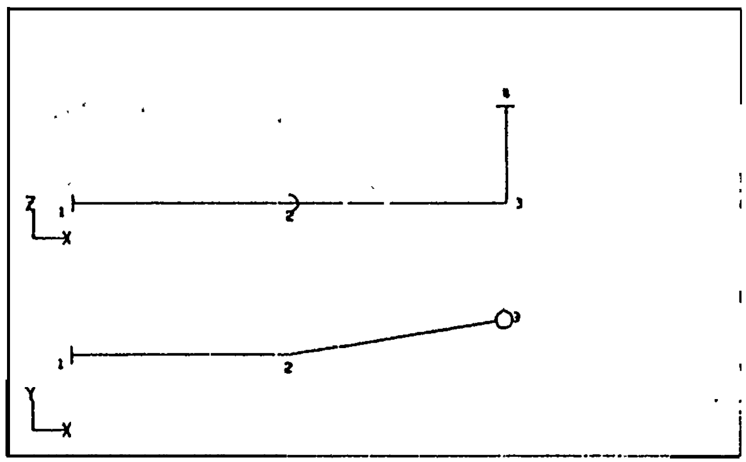
PRODUCTION INFORMATION

```
---------- < MATERIAL TABLE > -----------------  -< MANUFACTURING TABLE >-
POINT  NAME              ADJ. MATERIAL          NUM  CUT.L WELD  FA M.L BRANCH
 1- 4| JGB-    - 25-        |SGP-B                1   1421|         |
    4| F   - 10- 25-        |SS41                 1       | OK  0.0|
    1| F   - 10- 25-        |SS41                 1       | OK  9.5|
```

MATERIAL LIST

```
------------------------ < BENDING INFORMATION > ------------------------
1ST.P L  NC-L   FA     A  :  L  NC-L    RA     A  :  L  NC-L    RA    A
 1  1276| 776|+ 45.0  90.0: 610| 473| -90.0   9.4
```

BENDING INFORMATION



SHAPE OF PIPE PIECE (PROJECTION)

```
--------------------- < MEASUREMENTS OF PIPE PIECE > -------------------
 FM TO|KIND|ANG OTHER| NAME          |    X |    Y |     Z |N| AL&L|MAG.L
   - 1|FL  |         | F  - 10- 25-  |      |      |       | |     |
 1- 2|BR   |  9      |               |  600|      |       | |  600|
 2- 3|BR   | 90      |               |  600|   100|       | |  608|
 3- 4|FL   |         | F  - 10- 25-  |      |      |    278| |  278|
** TOTAL LENGTH: X- 1200 Y-  100 Z-  278 ***** TOTAL WEIGHT:      6KG *****
```

MEASUREMENTS OF PIPE PIECE

```
M:  /  IC:  /  IB:  /  IF:  /  IW:  /  IG:  /  IS.  /  IE:  /  IH.  /
```

***** VALVE LIST (FOR PURCH. ORDER) *****

* SNO 4432
* GLOBE & ANGLE VALVE (CAST STEEL)

OPERATION
M : MANUAL S : SELF OP.
H : HYDRAULIC E : ELECTRIC
PN : PNEUMATIC
RH : REACH ROD = HANDLE
RY : REACH ROD = YOKE

PURCH.ORDER
P- 12
4YH-1012

PAGE- 1

ALT. MARK	VALVE TYPE	RAT'G (K)	N.D. (MM)	MAT'RL	STANDARD	OPERATION	REQ. NO.	VALVE NO.		LOCATION	APPLICATION	WEIGHT (KG)	REMARKS
	GSV	10	100	SC	F7319	M	2	DSV- 2, 3		FWD. SPACE	DK STEAM	64,80	
	GSV	10	50	SC	F7319	M	2	DSV- 8, 9		UPPER DECK	DK STEAM	17,90	
	GSV	10	80	SC	F7319	M	1	DSV- 51		UPPER DECK	DK STEAM	29,80	
	GSV	10	100	SC	F7319	M	9	DSV- 4~ 7 DSV- 47~ 49 DSV- 52, 53		UPPER DECK	DK STEAM	64,80	
	GSV	10	125	SC	F7319	M	1	DSV- 50		UPPER DECK	DK STEAM	69,80	
	GSV	10	200	SC	F7319	M	1	DSV- 37		UPPER DECK	DK STEAM	158,00	
	GSV	10	250	SC	F7319	M	1	DSV- 46		UPPER DECK	DK STEAM	257,00	
	GSV	10	65	SC	F7319	M	2	DSV- 34, 35		AUX. P. RM.	DK STEAM	26,10	
	GSV	10	125	SC	F7319	M	1	DSV- 36		AUX. P. RM.	DK STEAM	69,80	
	GSV	10	100	SC	F7319	M	2	DSV-100,103		AFT. SPACE	DK STEAM	44,80	
	GSV	10	150	SC	F7319	M	2	DEV- 24, 27		MAIN P. RM.	DK EXHAUST	96,30	
	GSV	10	250	SC	F7319	M	3	DSV-125,127 DSV-128		MAIN P. RM.	DK STEAM	257,00	
	GSV	20	100	SC	F7313	M	6	DSV-110,112 DSV-114,115 DSV-117,119		MAIN P. RM.	DK STEAM	62,30	
	GSCV	20	250	SC	F7473	RH	1	SOV-117		MAIN P. RM.	STRIPPER	349,00	
	ASCV	10	50	SC	F7472	M	2	DSV- 62, 63		UPPER DECK	DK STEAM	16,30	
	ASCV	5	300	SC		H	1	WBV-105		MAIN P. RM.	WATER BALLAST	310,00	

HICAS-P TABLE OF PIPE PIECES

-------- HICAS-P TABLE OF CONTENTS --------
(FOR PIPE PIECE DRW.)

**** ZINC PLATING
**** DIVISION=H ; S.NO=0099
**** BOOKLET =9951-422-123

(WEIGHT:KG LENGTH:M) DATE=10/25/77 PAGE= 2

PAGE	PIPE PIECE NO.	NOMINAL -DIA.	ELBOW	LENGTH	TREAT MENT	PAINTING IN	PAINTING OUT	TEST-PRRS	BOSS	BRAN CH	ADJU ST	OUT-ZONE	WEIGHT	REMARKS
1	FW- 1-11-	20	0	1.5	G	R -2	N -	A-150	0	0	ADJUS	HU	3.3	
2	FW- 1-12-	20	0	2.0	G	R -2	N -	A-150	0	1		HU	4.4	
3	FW- 1-13-	15	0	0.8	G	R -2	N -	A-150	0	0		HU	2.1	
4	FW- 1-14-	40	0	2.2	G	R -2	N -	A-150	1	0		HU	9.0	
5	FW- 23-01-	20	2	0.9	G	R -2	-	A-150	0	0		HU	4.3	
6	FW- 23-02-	20	1	0.6	G	R -2	-	A-150	0	0	ADJUS	HU	4.5	
7	FW- 23-03-	15	0	5.0	G	R -2	-	A-150	0	0		HU	6.8	
8	FW- 23-15-	50	0	1.5	G	R -2	-	A-150	1	0		HU	15.1	
9	FW- 23-16-	40	0	0.9	G	R -2	-	A-150	0	0		HU	8.5	
10	FW- 23-17-	40	0	1.6	G	R -2	-	A-150	0	0	GEN	HU	7.9	
11	FW-123-11-	40	0	2.3	G	R -2	N -	A-150	0	1		HU	16.0	
12	FW-123-12-	125	2	1.2	G	R -2	N -	A-150	0	0		HU	125.7	

HICAS-P BILL OF MATERIALS

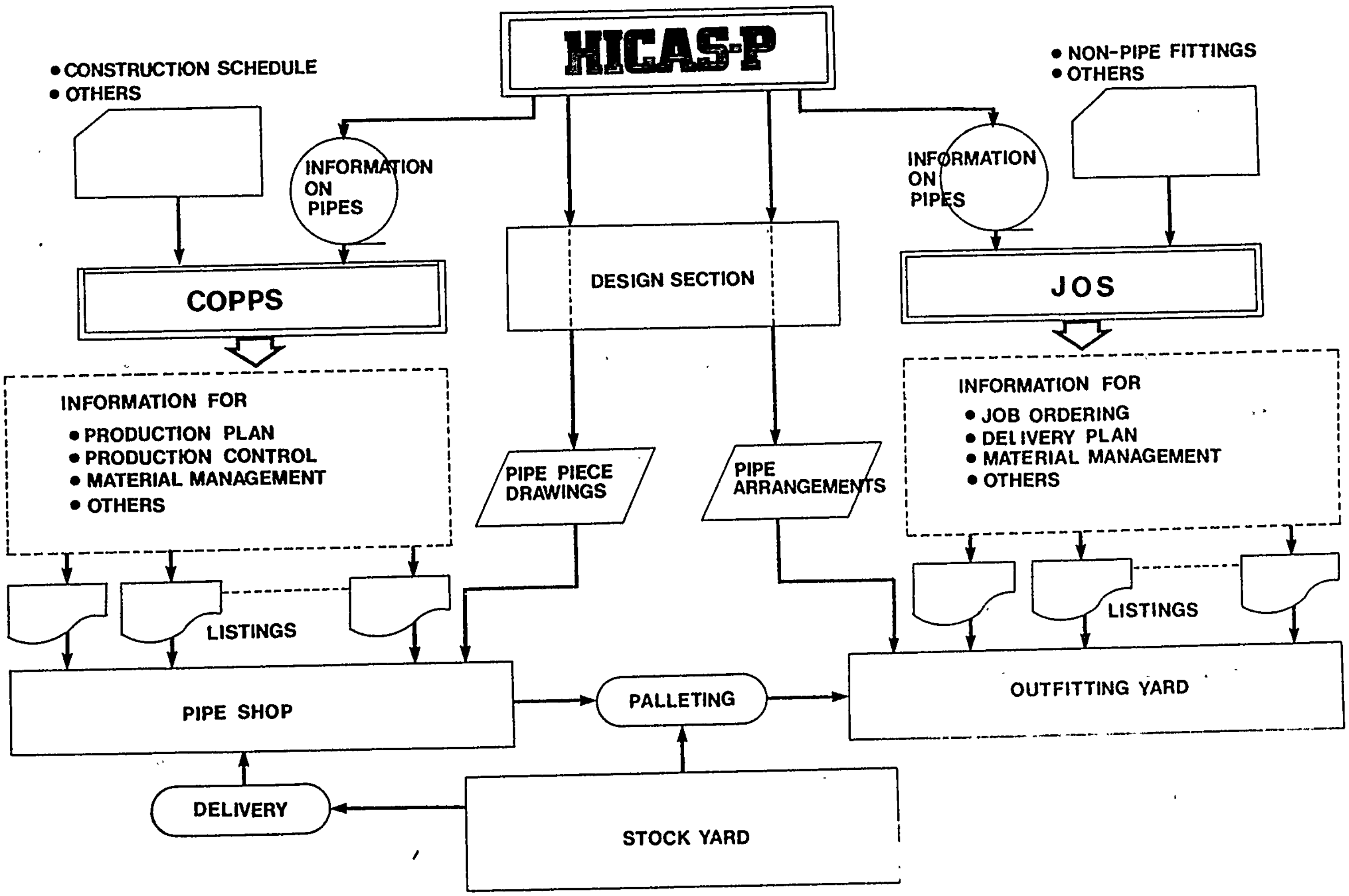
---------- HICAS-P TABLE OF MATERIALS ----------

```
**** DIVISION=H ; S.NO=0099
**** (LOKLET =9951-422-123

**** MATERIAL=RAW PIPE
```

DATE=10/21/77 PAGE= 2

MIS CODE - MATL NAME	DIMENSION	MATERIAL	P. CD		FW	CO											TOTAL LENGTH (M)	TOTAL WEIGHT (KG)
41352-3205	15- 2.8	SGP-E	90		6	0	0	0	0	0	0	0	0	0	0	0	6	8
41352-3206	20- 2.8	SGP-E	90		6	0	0	0	0	0	0	0	0	0	0	0	6	10
41352-3209	40- 3.5	SGP-E	90		9	0	0	0	0	0	0	0	0	0	0	0	9	35
41352-3210	50- 3.8	SGP-E	90		1	0	0	0	0	0	0	0	0	0	0	0	1	5
				TOTAL	22	0	0	0	0	0	0	0	0	0	0	0	22	58
41353-3309	40- 3.7	ABG-2-S #40	11		0	13	0	0	0	0	0	0	0	0	0	0	13	53
41353-3310	50- 3.9	ABG-2-S #40	11		0	11	0	0	0	0	0	0	0	0	0	0	11	59
41353-3311	65- 5.2	ABG-2-S #40	11		0	1	0	0	0	0	0	0	0	0	0	0	1	9
41353-3315	125- 6.6	ABG-2-S #40	11		2	0	0	0	0	0	0	0	0	0	0	0	2	43
				TOTAL	2	25	0	0	0	0	0	0	0	0	0	0	27	164
		G.TOTAL		LENG	24	25	0	0	0	0	0	0	0	0	0	0	49	
				WT	101	121	0	0	0	0	0	0	0	0	0	0		222

HICAS-P ADMINISTRATIVE INFORMATION SYSTEM



SCHEDULE OF PIPE PIECE FABRICATION

カコウサク ヨテイヒョウ

Date axis: 76/12/ (days 15–31), 77/01/ (days 1–20)

SNO. シヨシヨ	SHEET NO. SC L M N	NI	W P	シヨ ケイ	タイ ケイ	ヒテ ツ	スイ アツ	アウ ト	チヨ カン	エダ スウ	ライ ニン	アル マー	ケツ コウ	ノウキ	Schedule
4534 H	HC-C P 1- 2- 1	04	394 33	27	0	6	0	18	28	2	0	0	0	01/25	MMMM BBBB FF WW GG SSS S
4555 H	D1-CU P 2- 3- 1	01	8415 154	117	37	0	0	18	96	14	0	0	0	01/25	BBB F FFFF W WWWWW WWWW GGGGGG G SS SSS S
4555 H	D2-CU P 2- 4- 1	02	80 3	3	0	0	0	1	2	0	0	0	0	01/25	MMMM BBBB FF WW GG SSS S
4555 H	T2-C1 P 3- 4- 1	01	872 6	6	0	0	0	0	0	0	0	0	0	01/25	MMMM BBBB FF WW GG SSS S
4571 H	C2-SC P 3- 3- 1	04	780 4	0	4	0	0	0	0	0	0	0	0	01/25	M BBB FFFFF WWW GG SSSSS
4554 H	HA-GC 1- 5- 2	B	34 18	7	0	11	0	14	6	0	0	0	0	01/28	M M FF FFF WW W GG
4554 H	HB-SC 1- 5- 1	B	100 21	12	0	8	0	2	10	0	0	1	0	01/28	M M FF FFF WW W GG

PIPE CUTTING PLAN

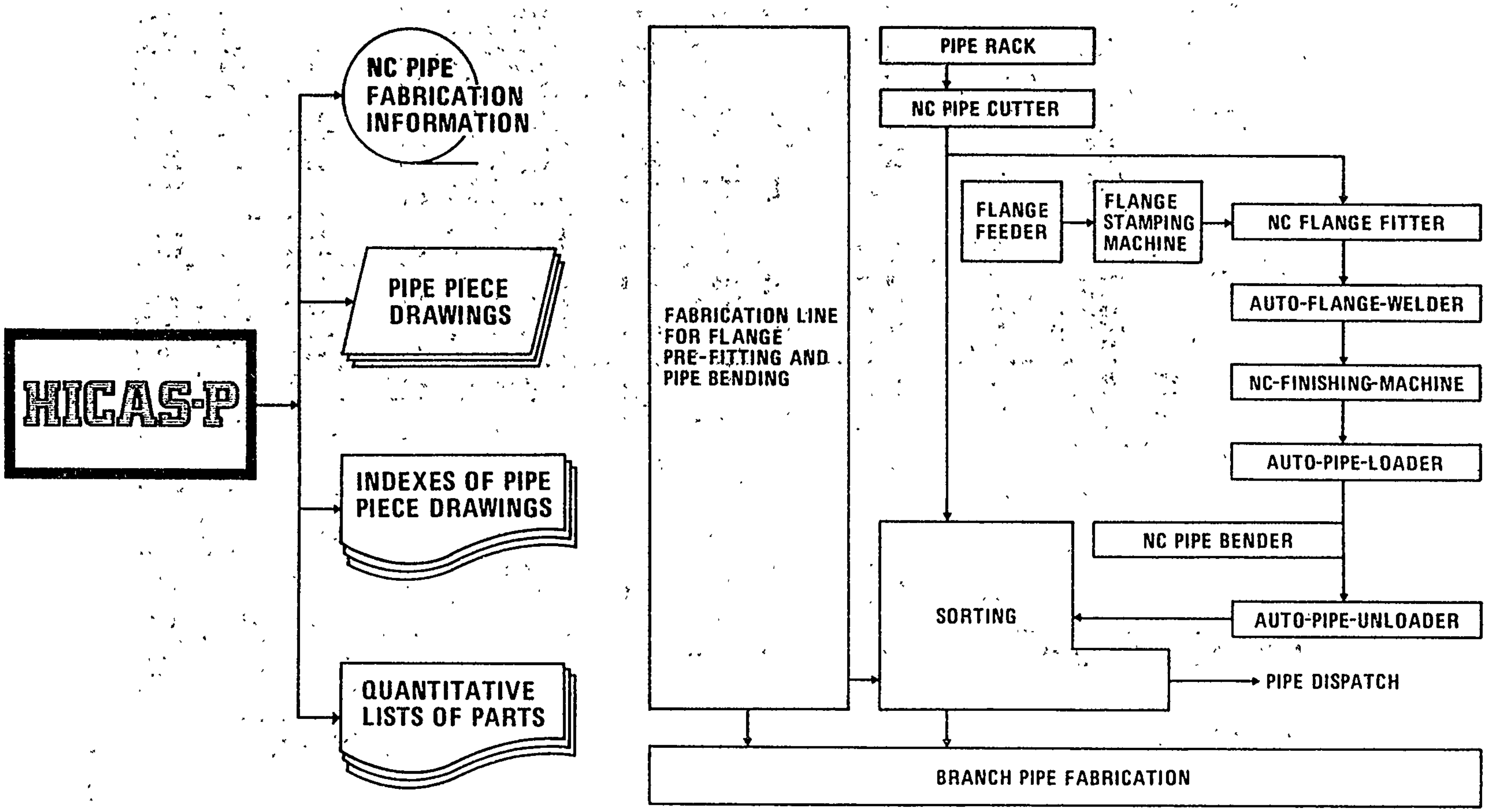
ﾃｲﾗｸ ｶﾂﾃｲﾝｸﾞﾌﾟﾗﾝ

PAGE 5

ｶｺｳﾛｯﾄ : L1-01-010   ｼﾖﾘﾋﾞ : 76/04/27

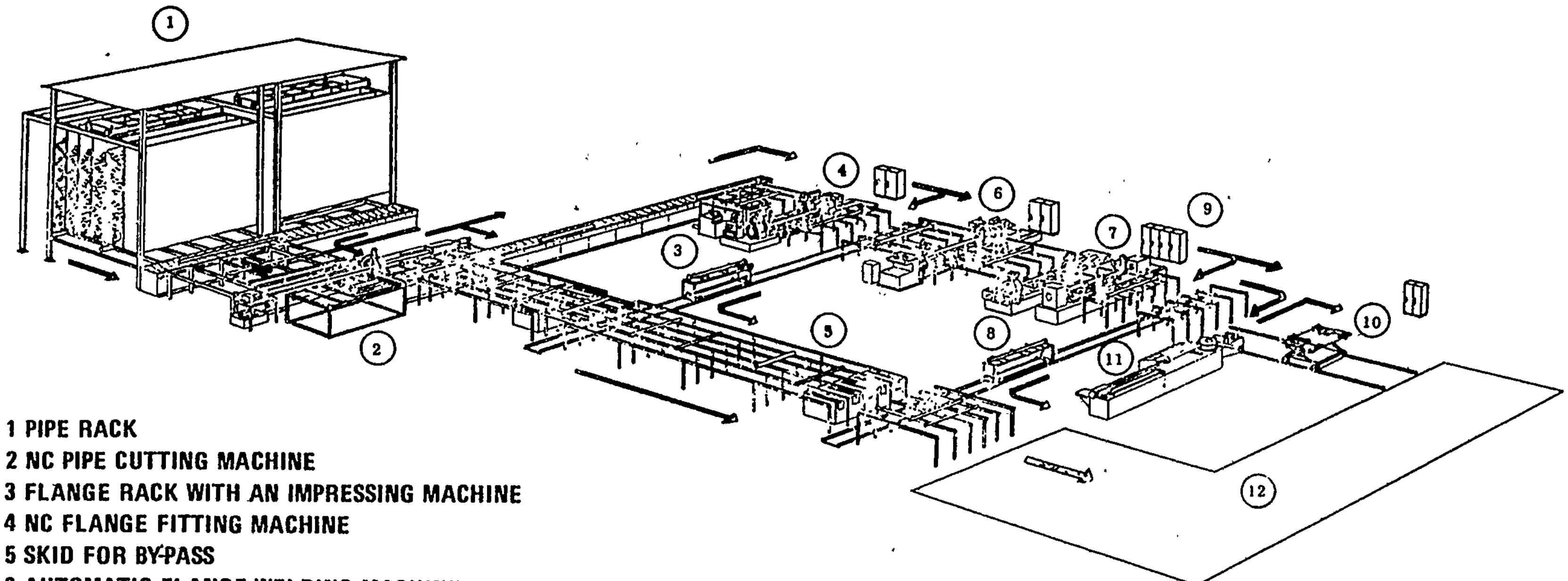
ｾﾝﾊﾞｺﾞ	ｶﾝｻﾞｲ	ｼﾕﾙｲｶﾀｼｷ	ｺｰﾄﾞ				M	ｶﾝﾌﾞｺﾞｳ	ｾｲﾊﾞｺ	ﾃｲｼﾔｸ	ｶｲｻｷ	ﾅｶﾞｻ	ｻﾞﾝｻﾞｲ	ﾊｻﾞｲ	ｼﾕｳｹｲ
14484	JE4-	- 50-	0.0	0.0	STPG38-E	E 40	B	SA- 30- -	HU-AC	5500		617			
14484	JE4-	- 50-	0.0	0.0	STPG38-E	E 40	B	SA- 2- -	HU-AC	5500		617			
14484	JE4-	- 50-	0.0	0.0	STPG38-E	E 40	B	SA- 1- -	HU-AC	5500		917			
14484	JE4-	- 50-	0.0	0.0	STPG38-E	E 40	B	SA- 29- -	HU-AC	5500		917	2412		1
14484	JE4-	- 40-	0.0	0.0	STPG38-E	E 40	S	SA- 44- -	HU-AC	5500		1092			
14484	JE4-	- 40-	0.0	0.0	STPG38-E	E 40	S	SA- 17- -	HU-AC	5500		1092			
14484	JE4-	- 40-	0.0	0.0	STPG38-E	E 40	B	SA- 18- -	HU-AC	5500	V 1	1253			
14484	JE4-	- 40-	0.0	0.0	STPG38-E	E 40	B	SA- 43- -	HU-AC	5500	V 1	536			
14484	JE4-	- 40-	0.0	0.0	STPG38-E	E 40	B	SA- 45- -	HU-AC	5500		677		815	1
14484	JGE-	- 40-	48.6	3.5	SGP-E	E	B	RA- 3- -	HU-AC	5500		1392			
14484	JGE-	- 40-	48.6	3.5	SGP-E	E	B	RA- 4- -	HU-AC	5500		822	3276		1
14484	JE4-	- 32-	0.0	0.0	STPG38-E	E 40	B	SA- 25- -	HU-AC	5500		806	4689		
14484	JE4-	- 32-	0.0	0.0	STPG38-E	E 40	B	SA- 52- -	HU-AC	5500		806			
14484	JE4-	- 32-	0.0	0.0	STPG38-E	E 40	B	SA- 28- -	HU-AC	5500	V 1	835			
14484	JE4-	- 32-	0.0	0.0	STPG38-E	E 40	B	SA- 27- -	HU-AC	5500		1384			
14484	JE4-	- 32-	0.0	0.0	STPG38-E	E 40	B	SA- 54- -	HU-AC	5500	V 1	1086			
14484	JE4-	- 32-	0.0	0.0	STPG38-E	E 40	B	SA- 26- -	HU-AC	5500		1134		220	2
14484	JE4-	- 25-	0.0	0.0	STPG38-E	E 40	B	SA- 48- -	HU-AC	5500		535			
14484	JE4-	- 25-	0.0	0.0	STPG38-E	E 40	B	SA- 6- -	HU-AC	5500	V 1	501	4449		
14484	JE4-	- 25-	0.0	0.0	STPG38-E	E 40	B	SA- 35- -	HU-AC	5500		1015			
14484	JE4-	- 25-	0.0	0.0	STPG38-E	E 40	B	SA- 47- -	HU-AC	5500		545			
14484	JE4-	- 25-	0.0	0.0	STPG38-E	E 40	B	SA- 9- -	HU-AC	5500		810			
14484	JE4-	- 25-	0.0	0.0	STPG38-E	E 40	B	SA- 34- -	HU-AC	5500	V 1	843			
14484	JE4-	- 25-	0.0	0.0	STPG38-E	E 40	B	SA- 33- -	HU-AC	5500	V 1	951			
14484	JE4-	- 25-	0.0	0.0	STPG38-E	E 40	B	SA- 5- -	HU-AC	5500	V 1	951		340	
14484	JE4-	- 25-	0.0	0.0	STPG38-E	E 40	B	SA- 10- -	HU-AC	5500	V 1	1546			
14484	JE4-	- 25-	0.0	0.0	STPG38-E	E 40	B	SA- 7- -	HU-AC	5500		1168			
14484	JE4-	- 25-	0.0	0.0	STPG38-E	E 40	B	SA- 19- -	HU-AC	5500		1118			
14484	JE4-	- 25-	0.0	0.0	STPG38-E	E 40	B	SA- 23- -	HU-AC	5500		1025			
14484	JE4-	- 25-	0.0	0.0	STPG38-E	E 40	B	SA- 22- -	HU-AC	5500		585		28	3
14484	JGE-	- 25-	34.0	3.2	SGP-E	E	B	YD- 4- -	HU-AC	5500	V 1	1095			
14484	JGE-	- 25-	34.0	3.2	SGP-E	E	B	YD- 8- -	HU-AC	5500	V 2	751			
14484	JGE-	- 25-	34.0	3.2	SGP-E	E	B	YD- 5- -	HU-AC	5500	V 1	721	2898		1
TOTAL															9

HICAS-P TYPICAL FLOW OF NC PIPE FABRICATION SYSTEM



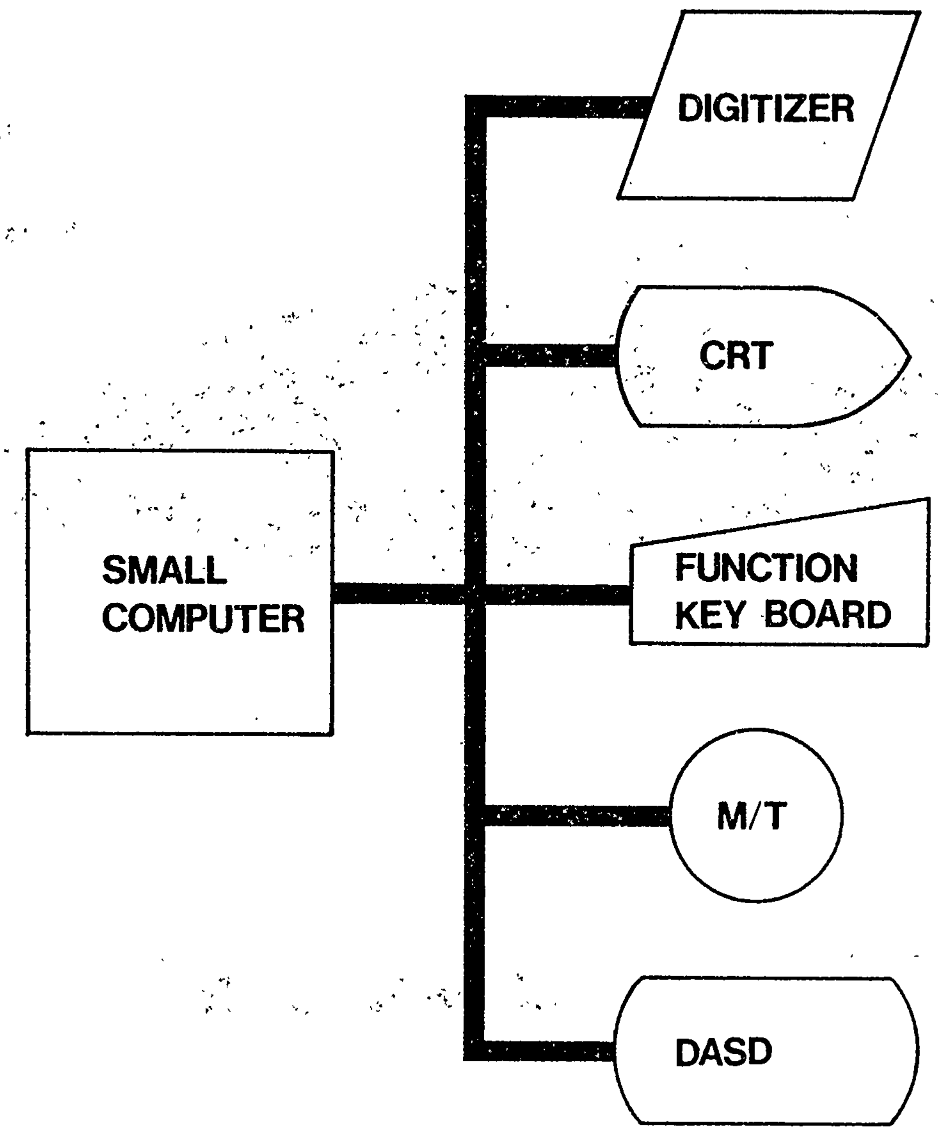
HICAS-P

NC PIPE SHOP

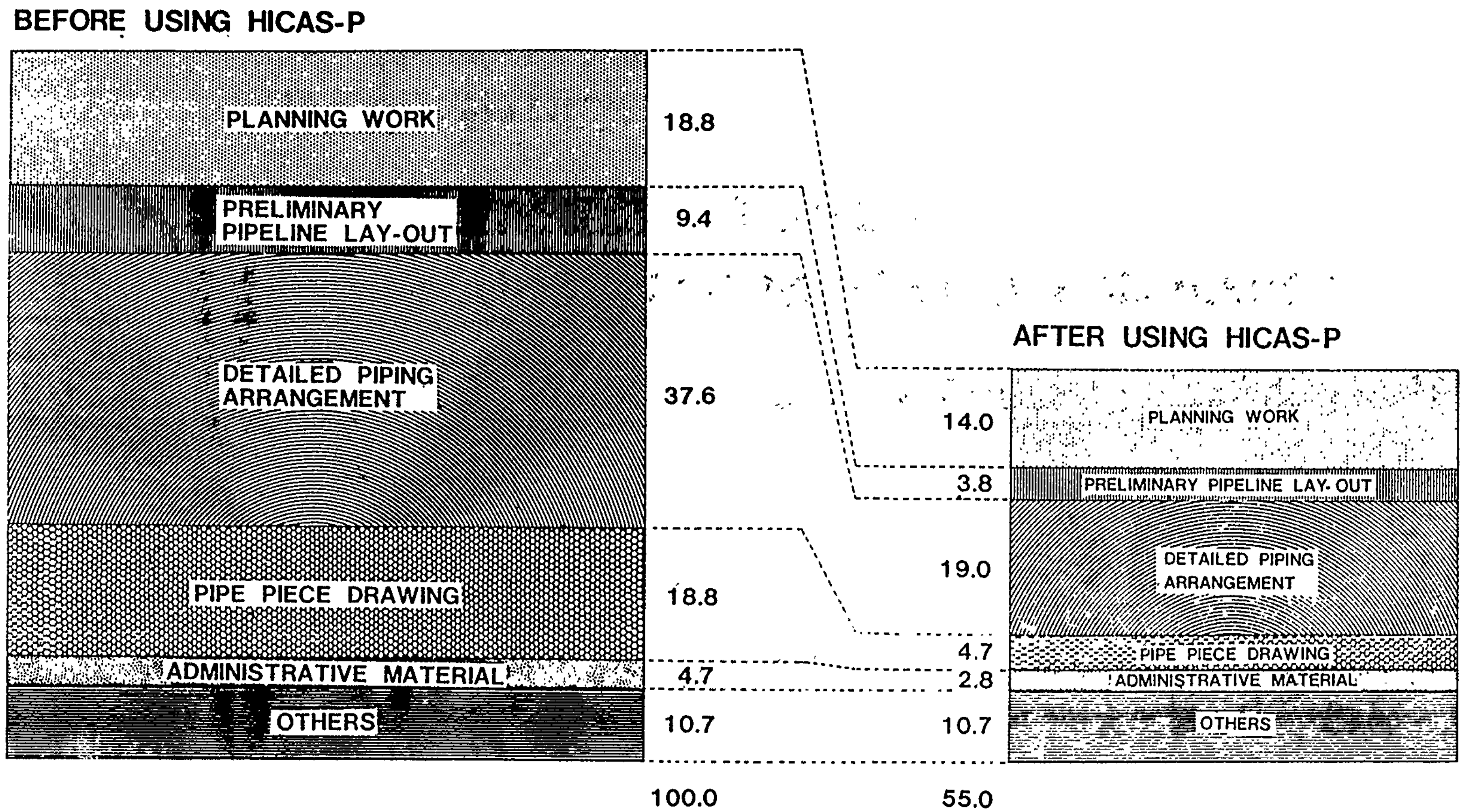


1 PIPE RACK
2 NC PIPE CUTTING MACHINE
3 FLANGE RACK WITH AN IMPRESSING MACHINE
4 NC FLANGE FITTING MACHINE
5 SKID FOR BY-PASS
6 AUTOMATIC FLANGE WELDING MACHINE
7 NC PIPE FINISHING MACHINE
8 DOLLY FOR BY-PASS
9 CONTROLLER
10 PIPE UNLOADING DOLLY
11 NC PIPE BENDER
12 SORTING STAGE

HICAS-P PF HARDWARE CONFIGURATION



HICAS-P HIGH EFFICIENCY



HICAS-P

EFFECT

- REDUCTION OF PIPING DESIGN TERM
- PREVENTION OF ERRORS IN DESIGN & MANUFACTURE
- NOT WANTED SKILLED PIPING DESIGNER
- INFORMATION SUPPLY FOR PIPING CONTROL SYSTEM
- OTHERS

THE SPADES SHIP PRODUCTION AND CONTROL (SPAC) MODULE

Filippo Cali
Cali and Associates, Inc.
Metairie, Louisiana

Since the founding of Cali and Associates, Mr. Cali has directed the continuous development of the SPADES system and expanded the company to provide complete N/C lofting services to the shipbuilding industry. He has 30 years of experience in all phases of shipbuilding.

Mr. Cali has a degree in engineering ’from the Italian Naval Academy.

GENERAL COMMENTS AND INTRODUCTION

The purpose of this writing is to report the present status of development and implementation of the 'SPAC' Module.

The 'SPAC' Module was originally conceived two years ago, and the justification for its development is just as valid today as it was then. Actually, our increasing experience in operating a service center for N/C Lofting has provided additional reasons for generating other computer outputs not conceived originally to reduce lofting man-hours and better control shedules, as shown later.

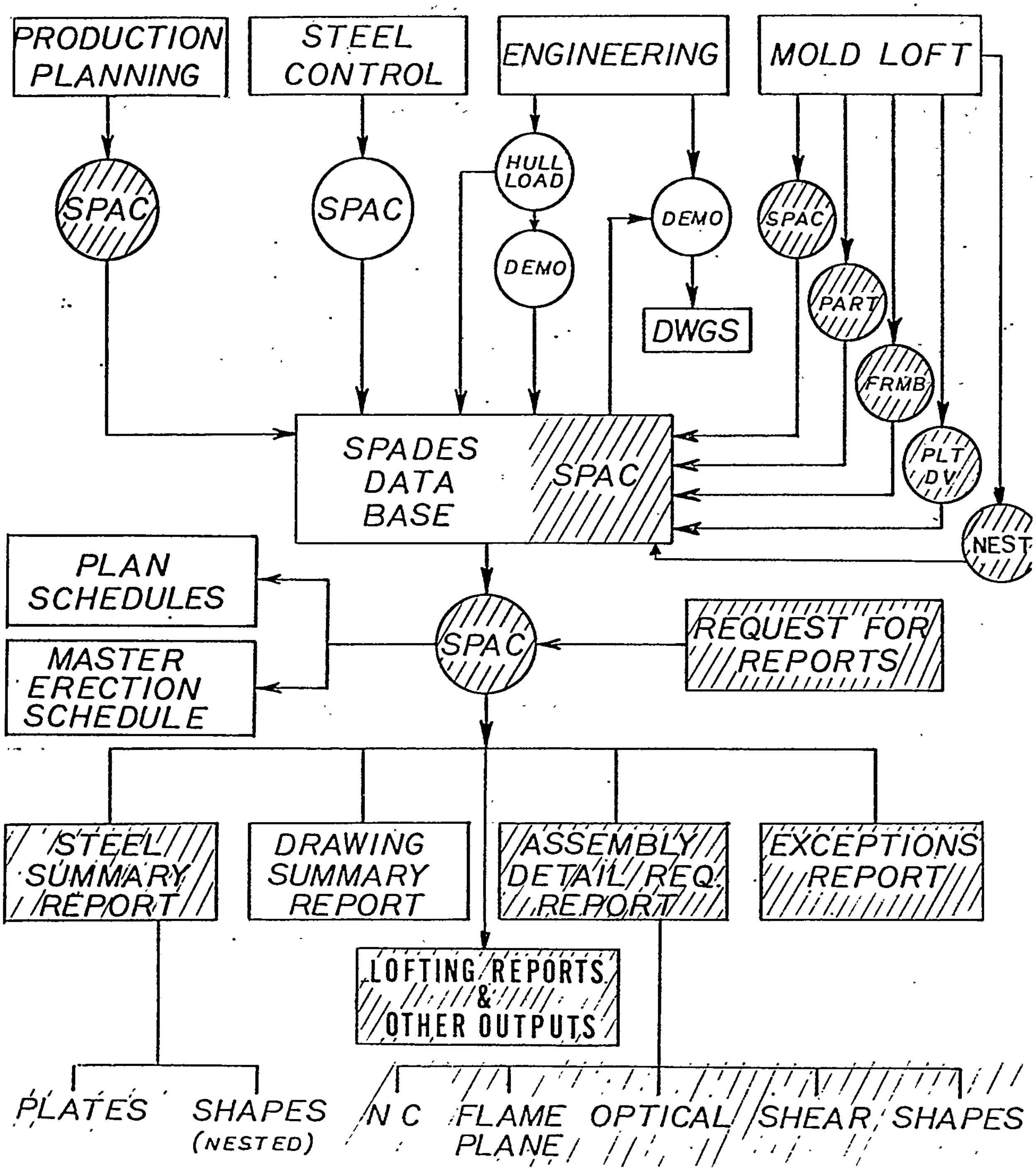
It should be mentioned at this point that the labeling capabilities added to the 'SPADES' System in general because of the 'SPAC' Module will make it desirable to upgrade the hardware used in the loft and in the shop. A fast drafting machine should be used in those shops with a high work load, and a 'DNC' mode of operation will allow not to punch a high volume of paper tape.

Provisions have also been made for transferring all applicable labeling and lofting markings to the burning machine. To do so today for all tapes will probably overload the burning machine. I feel that the use of this feature is justifiable at the present only when using the burning machine for cutting templates from light gauge sheet metal or aluminum, since this operation will represent only a small percentage of the total work load. Total use of it will probably have to wait until better marking systems are available, although some shipyards with surplus N/C cutting capability might find it desirable, even with today's hardware. The zinc oxide marker is probably the best tool to use at the present for this purpose

SPADES SYSTEM

Figure 1

DATA FLOW FOR SHIP PRODUCTION AND CONTROL MODULE



STATUS REPORT

Figure 1 is a copy of the 'data flow' conceived for 'SPAC' originally; and since no major changes have occurred during the 'development, it is used to report on the present status.

The status as reported herein is not in terms of coding done yet to be tested. The shaded areas represent the actual extent of 'SPAC' as presently in production use by our N/C Lofting Department.

Implementation was started last October, and the various examples shown later are working documents for a notch tug we are in process of lofting for Atlantic Marine, Inc., in Jacksonville, Florida.

The detail status report is as follows:

A. Data Base

Expansion of the data base to accommodate all records requirements for 'SPAC' has been completed. Proper provisions have also been made for all other ship systems other than steel, such as: piping, HVAC, outfitting, etc. It is expected that some new handling routines will become necessary as the development continues.

B. 'SPAC' Program

At the present,. this program allows the loft and production planning to communicate with the data base for initial loading of assembly (unit) breakdown; to assign schedules and personel and enter data.. such as validation of individual items. It is also used to request all reports except those generated automatically by the system when applicable.

As the experience in the use of 'SPAC' increases, it is inevitable that changes and additions will be incorporated.

C. 'PARTGEN', Framebending, Plate Development and Nesting

The necessary modifications in these modules to integrate with 'SPAC' have been completed and no further changes for this purpose are expected.

I am pleased to report that the additional input requirements in these modules is very minimal and very simple. Furthermore, it has been structured in such a way, not to require any modification of past input.

D . 'SPAC' Reports

All reports shown shaded in Figure 1 are complete and available to the user. I am sure that format changes and added information will be requested by the 'SPADES' users other than ourselves to better suit the practices of the various shipyards. Under the guidance and with the approval of the 'SPADES' Users' Steering Committee, we will incorporate such changes,

E. Lofting Reports and Other Outputs

These reports have been added during the development to aid the loft in tracking the work in progress, and to minimize clerical errors of identification, such as mislabeling a part, or showing the thickness throw on the wrong side of the molded line. The latter will prove very valuable in reducing man-hours and turn around time associated with design and production changes, or with rework due to errors.

F. On-Going Development

The various records presently stored in the data base contain more information than is utilized by the various 'reports. One good example is the three-dimensional center of gravity associated with each piece. High on the list of priorities is the generation of the weight and center of gravity by assembly and for the entire ship.

Within the practical space limitations of this paper, it would be difficult to include a full, complete 'SPAC' report for an entire module. For a better understanding, Pages 7 through 40 have been, collected to give the interested reader a quick walk through the lofting process and its tie-in with the 'SPAC' Module.

Frame Bending Module

Page 7 is part of a drawing showing a shell longitudinal (L- 12) terminating at Fr. 54. The longitudinal belongs to Module 1 and is contained in Drawing 777. The Pc. Mk. is l-777LI20540P. Page 8 shows the input coding (from Longitudinal L-7 to L-12). Pages 9 and 10 are the

end-cut templates at the forward end of the beam. Page 11 is a tabulation of the developed curvature to enable the making of a full stale template. Page 12 is a typical summary printed for ,. each beam.

Page 13 (Line 61) is a page of the 'SPAC' Report for Module 1, showing all data needed and templates to be used to fabricate and bend the longitudinal in the shop.

Plate (Shell) Development Module

Page 14 is portion of the shell expansion drawing (777) showing Shell Plate C -2. The Pc. Mk. is 1-.777C 2: S. Page 15 is the input for this plate and three other plates. The same input is used for the roll sets. Page 16 is the plot of the developed part. Page 17 shows the corresponding roll sets. Page 18 is part of the nested tape to cut the roll sets from surplus material. Pages 19 and 20 are the title block and plot location of the templates within the nested Tape No. -741011, Rev. 2. The digit '4' in this number indicates that these are templates and not parts. Page 21 (Line 21) lists tape and template needed to cut and roll the plate. Page 22 (Line 55) shows that Template 8023-401 is nested within Tape No. 741011 and is to be used for Pc. Mk. 777. C 2 S.

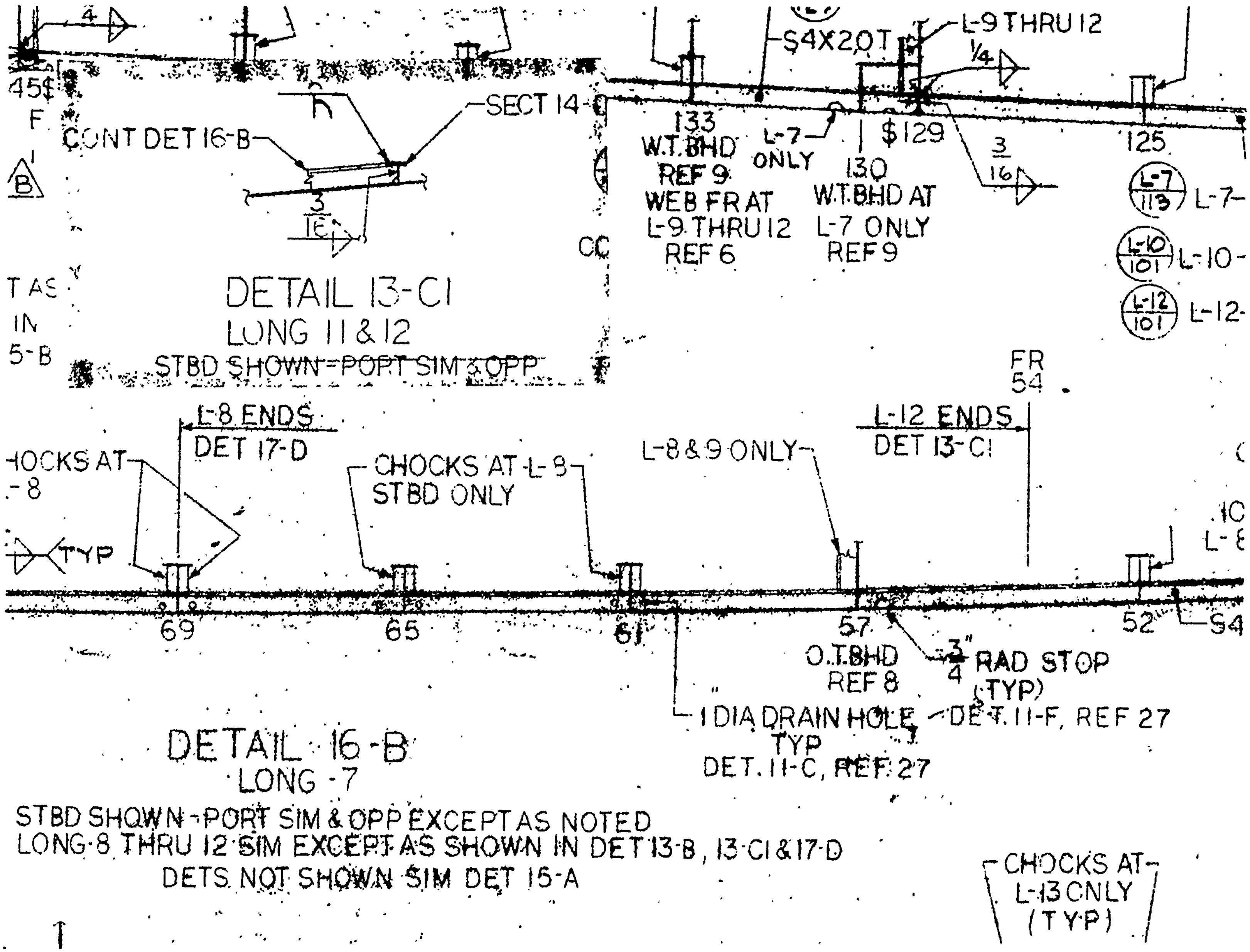
Part Generation Module

Page 23 (Dwg. 786) shows a transverse bulkhead (Pc. 174) and associated vertical stiffness within Module 2.07. The bulkhead Pc. Mk. is 2. 0.7-786085017.4C. The stiffener shown (172) has Pc. Mk. 1-78.61720850 S. Page 24 is the input coding. Page 25 is the tabulation of the part geometry. Page 26 is the plot of the part (Note the thk. throw from the molded line plotted by the drafting machine). Page. 27 is the input for all stiffeners on the bulkhead. The four lines for 2.0.7-7861720850 S are bracketed. Pages 28 to 31 are the end-cut templates. Page 32 (Line 20) shows cut length, other data and template associated with the stiffener.

Nesting Module

Page 33 is the input for Nest Tape No. 710039 calling for the above bulkhead. Pages 34, 35 and 36 are title block, plot location of parts, and summmary report for the tape. On Page 35, the bulkhead, (Pc. Mk. 2. 07-786850174 C) is Item No. 9. Page 37 (part of the plot of the tape) shows the piece marked 9. ., Page 38 is the proof drawing we deliver with each tape.

Page 39 lists the plates and tapes needed for Module 2.07, and Page 40 shows the tape number to be used to cut the bulkhead.



DETAIL 13-C1
LONG 11 & 12
STBD SHOWN - PORT SIM & OPP

DETAIL 16-B
LONG-7

STBD SHOWN - PORT SIM & OPP EXCEPT AS NOTED
LONG-8 THRU 12 SIM EXCEPT AS SHOWN IN DET 13-B, 13-C1 & 17-D
DETS NOT SHOWN SIM DET 15-A

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

INPUT EXECUTE             DATE  05/29/78     TIME  22/24/58      RUN NO.    5
JOB PB01  PROG. MAID  FRED         INPUT 0032     REV. NO.    4         PAGE   1

INPS                    N       32                                       7800320004
RMKS   JESSE                                                             7800320008
MODL     1                                                               7800320012
DRWG 777      16-B                                                       7800320016
LONG                     M           S L7        S L12                   7800320120
NADT   S4X2.0T          N       904                                      7800320124
PCMK  777L 70470 P       S L7                                            7800320128
      777L 80470 P       S L8                                            7800320132
      777L 90470 P       S L9                                            7800320136
      777L100470 P       S L10                                           7800320140
      777L110470 P       S L11                                           7800320144
      777L120540 P       S L12                                           7800320148
BUTT                     F 47      Z1      .324  F 73.    Z       2 0    7800320152
ECUT                  A*           S         1 8 A*       S       1 8    7800320156
OPTN FLG1FLG2TABL                                                        7800320176
MARK ALL                                                                 7800320180
DEFN                     S L8                                            7800320252
BUTT                     F 47.     Z1      .324  F 69.                   7800320256
DEFN                     S L9                                            7800320257
BUTT                     F 47.     Z1      .324  F 73.    Z       2 0    7800320259
DEFN                     S L12                                           7800320260
BUTT                     F 54      Z1      .188  F 73.    Z       2 0    7800320264
ECUT                  A*           S         1 8 A*       S       1 8    7800320268
OPTN FLG1FLG2TABL     I    1.406                                         7800320272
INPE                                                                     7800329999
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

                INPUT IS EXECUTABLE FROM       WITH REV.    4
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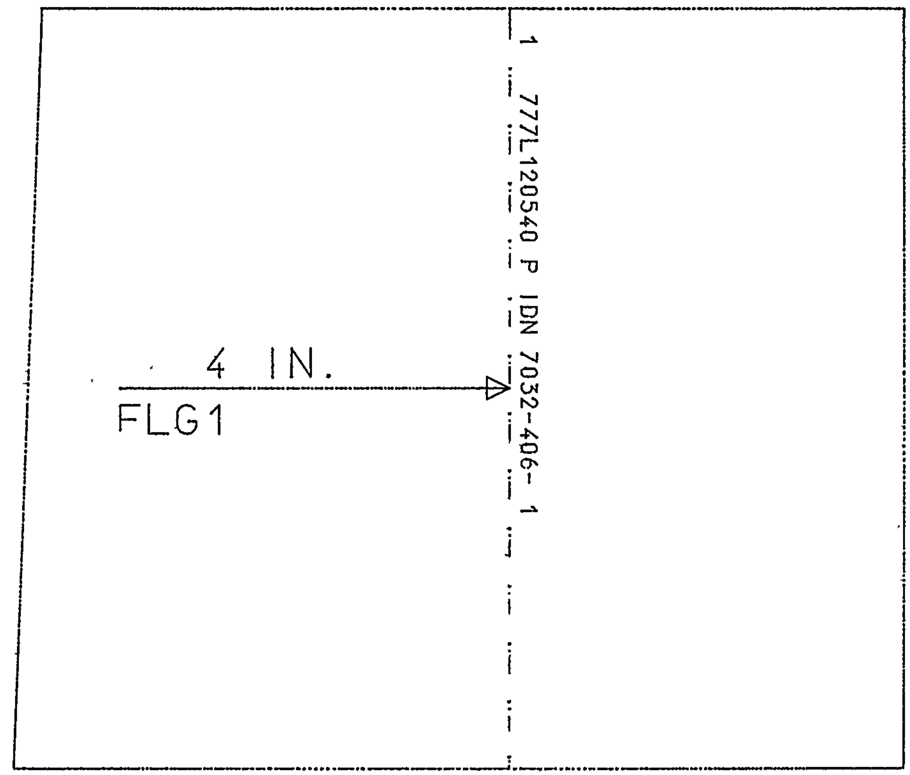
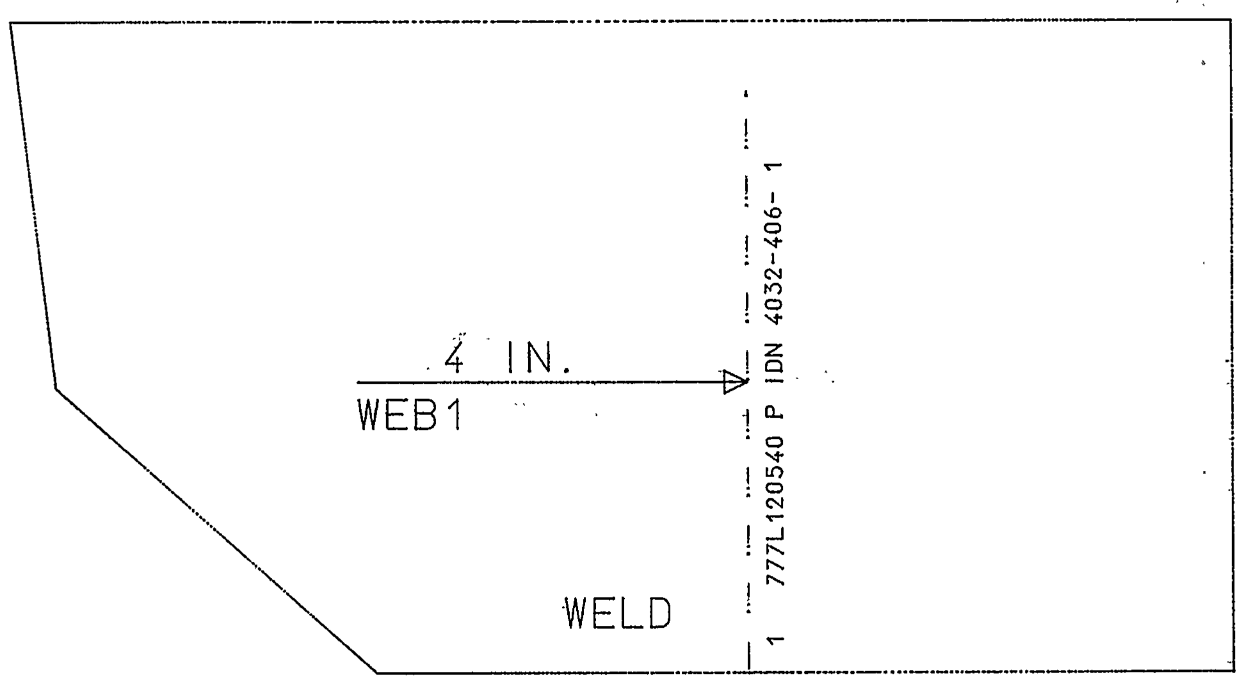


TAPE NO. 787032-406- 1



TAPE NO. 784032-406- 1

257

DATE 04/24/78
YARD JOB NO. 7005PR01
D.B. NAME   P001
D.B. JOB NO.   7

S P A D E S   S Y S T E M

UTILITY MODULE - U101

PAGE 1

PIECE IDN. 6052-406 REV. 1 (FRAME FRND. TABLE) PCMP. 1 777L120540 P DWG. 777 16-6

S 4X2.0 T AL5086 LONG FRAME S L12 P OF SHIP'S SURFACE M F

T A B L E   O F   O F F S E T S

DISTANCE (Y) OF THE TRACE FROM THE CHORD AT LOCATION (X) IN FT-IN-16

MARK		R FWD				F 57.000			F 59.050	
X	0- 0- 0	0- 3- 7	1- 0- 0	2- 0- 0	3- 0- 0	3- 0- 1	4- 0- 0	5- 0- 0	5- 0- 4	6- 0- 0
Y	0- 0- 0	- 0- 0- 1	- 0- 0- 3	- 0- 0- 5	- 0- 0- 8	- 0- 0- 8	- 0- 0-10	- 0- 0-12	- 0- 0-12	- 0- 0-13

MARK		F 61.000			F 63.050			F 65.000		
X	7- 0- 0	7- 0- 7	8- 0- 0	9- 0- 0	9- 0-10	10- 0- 0	11- 0- 0	11- 0-13	12- 0- 0	13- 0- 0
Y	- 0- 0-14	- 0- 0-14	- 0- 0-15	- 0- 1- 0	- 0- 1- 0	- 0- 1- 1	- 0- 1- 1	- 0- 1- 1	- 0- 1- 0	- 0- 1- 0

MARK	F 67.000			F 69.000			F 71.050		F 72.100	R AFT
X	13- 0-15	14- 0- 0	15- 0- 0	15- 1- 2	16- 0- 0	17- 0- 0	17- 1- 4	18- 0- 0	18- 7- 6	18-11- 7
Y	- 0- 1- 0	- 0- 0-14	- 0- 0-13	- 0- 0-13	- 0- 0-11	- 0- 0- 6	- 0- 0- 8	- 0- 0- 5	- 0- 0- 3	- 0- 0- 1

MARK		F 73.000	
X	19- 0- 0	19- 1- 6	19- 3- 7
Y	- 0- 0- 1	- 0- 0- 1	0- 0- 0

```
DATE 06/07/78                                  S P A D E S   S Y S T E M
YARD JOB NO. 7005PB01
D.B. NAME    PB01                    PRODUCTION AIDS MODULE-FRAME BENDING PROGRAM
D.B. JOB NO.     7


                                          INDIVIDUAL BEAM SUMMARY REPORT

                                PIECE NO. 401 WITHIN INPUT DECK NO.  102 - RUN NO.  4

              3.08/78  41506 P      TRSV FRAME  F 150000P     ON SHIP'S SURFACE  L    64A P

              PHYSICAL PROPERTIES:
                                      SIZE                S 6X3.0 T AL5086
                                      NEUTRAL AXIS        4.356 INCHES
                                      DEPTH OF WEB        6.000 INCHES

              INPUT DEFINITION OF BUTTS AND END-CUTS :
                    BUTT                      PORG     X      15 0  PEND      X       -5 0
                    ECUT      SOCTSOCTSOCT N        15       1 8

              MINIMUM CUT-LENGTH REQUIRED :  2/ 0/11 FT/IN/16

              1ST. END-CUT REFERENCE MARK :  0/ 4/ 0 FT/IN/16 FROM END OF BEAM
                                             1/ 8/11 FT/IN/16 FROM THE OPPOSITE END
              2ND. END-CUT IS SQUARE - NO REF. MARK GIVEN

              ******************************** OUTPUT OPTIONS **********************************

                    OPTION           EXECUTED           STORED           DB.NO. AND REV.

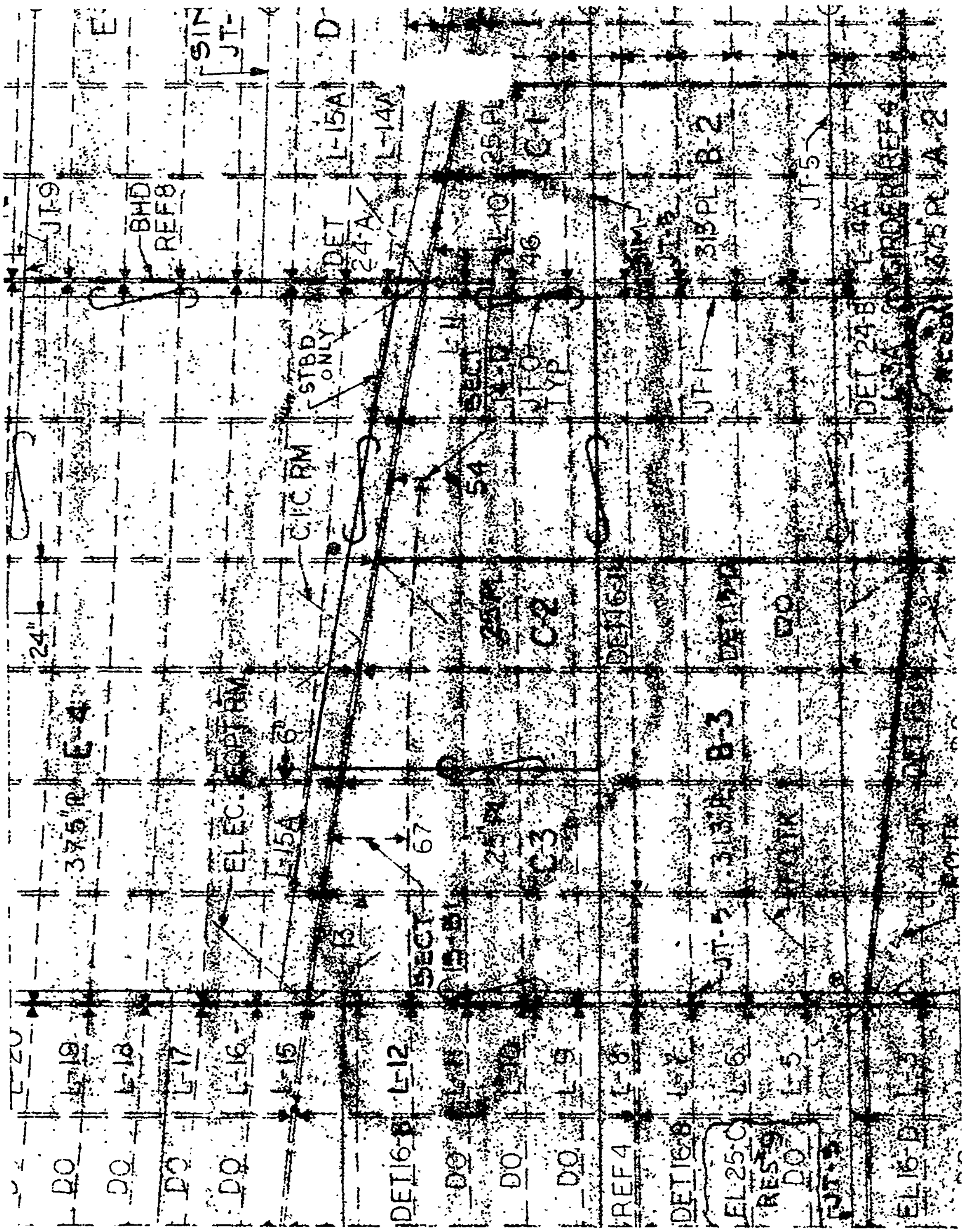
                     WEB1               YES               YES            6 4102-401- 2

                     TABL               YES               YES              6102-401- 2
```

258

PIECES PRODUCED FROM SHAPES

LINE-REV	PIECE MARK/ DRAWING NO.	QTY/ LOC.	WGT.	MAT'L	LENGTH	STK	'A'	'B'	'C'	N/C ID	WEB 1 / FLANGE 1	WEB 2 / FLANGE 2	OTHER N/C	AIDS
56- 8	777L100470 S	1	53	8S 904	26-04-04		25-08-04	4	4	6032-404- 2M	F4032-404- 2	A5032-404- 2	0	0
	777	16-F									7032-404- 2	9032-404- 2	LONG.FR.	FR.47
57- 6	777L110460 P	1	2	8S 904	1-00-08		- 4-08	4	4	6033-405- 1	F4033-405- 1	A5033-405- 1	0	0
	777	16-B									7033-405- 1	9033-405- 1	LONG.FR.	FR.46
58- 7	777L110460 S	1	2	8S 904	1-00-08		- 4-08	4	4	6033-405- 1M	F4033-405- 1	A5033-405- 1	0	0
	777	15-F									7033-405- 1	9033-405- 1	LONG.FR.	FR.46
59- 7	777L110470 P	1	53	8S 904	26-04-08		25-08-08	4	4	6032-405- 2	F4032-405- 2	A5032-405- 2	0	0
	777	16-B									7032-405- 2	9032-405- 2	LONG.FR.	FR.47
60- 8	777L110470 S	1	53	8S 904	26-04-08		25-08-08	4	4	6032-405- 2M	F4032-405- 2	A5032-405- 2	0	0
	777	16-B									7032-405- 2	9032-405- 2	LONG.FR.	FR.47
61- 5	777L120540 P	1	39	8S 904	19-03-14		18-07-14	4	4	6032-406- 1	F4032-406- 1	A5032-406- 1	0	0
	777	16-F									7032-406- 1	9032-406- 1	LONG.FR.	FR.54
62- 7	777L120540 S	1	39	8S 904	19-03-14		18-07-14	4	4	6032-406- 1M	F4032-406- 1	A5032-406- 1	0	0
	777	16-F									7032-406- 1	9032-406- 1	LONG.FR.	FR.54
63- 6	777L130690 P	1	6	8S 903	4-02-05		3-06-05	4	4	6040-401- 3	F4040-401- 3	A5040-401- 3	0	0
	777	15-B									7040-401- 3	9040-401- 3	LONG.FR.	FR.69
64- 7	777L130690 S	1	6	8S 903	4-02-05		3-06-05	4	4	6040-401- 3M	F4040-401- 3	A5040-401- 3	0	0
	777	15-B									7040-401- 3	9040-401- 3	LONG.FR.	FR.69
65- 11	782 20120 C	1	20	8F5-00	4-06-08					0			0	0
	782	4-A		X -12										
66- 11	782 70520 P	1	22	8F5-00	5-06-04					0			0	0
	782	3-E		X -12									FC.PLT.FR.51	


JT-9
BHD
REF8
DET
24-A
L-15A
L-14A
STBD
ONLY
C/C RM
24"
E-4
37.5"
ELEC.
L-15A
67
C2
C3
B-3
B-2
C-1
JT-5
JT-1
L-19
L-18
L-17
L-16
L-15
L-12
L-9
L-8
L-7
L-6
L-5
L-3
DO
DET16-B
REF 4
DET16-B
EL 25-C
RES-9

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

INPUT UPDATING           DATE  05/29/78     TIME  22/24/56      RUN NO.    5
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INPS                   N     8020                      570       1329         7580200004
RMKS   JESSE   5-6-78                                                         7580200008
MODL      1                                                                   7580200012
DRWG     777    5-B                                                           7580200016
BUIT                     J FWD       F 47.             6 0                    7580200120
                         J AFI       F 73.           - 6 0                    7580200124
                         J AF2       F 65.           - 6 0                    7580200128
LWSM                     J A                                                  7580200132
UPSM                     J D1                                                 7580200136
PART     777-A3 S       N         1                                           7580200140
SEAM          TRGL       J FWD       J A       J AFI     J B                  7580200144
REFL BUIK                  2 0 0                                              7580200148
PSTK                                                   2 0                    7580200152
MARK EXCL                F 54.       F 67.                                    7580200154
PLTE                   8I     .375                                            7580200156
PART     777-B3 S       N         2                                           7580200160
SEAM          TRGL       J FWD       J B       J AFI     J C                  7580200164
REFL BUIK                  6 0 0                                              7580200168
PSTK                                                   2 0                    7580200172
MARK EXCL                F 54.       F 67.                                    7580200174
PLTE                   8I     .313                                            7580200176
PART     777-C2 S       N         3                                           7580200180
SEAM          TRGL       J FWD       J C       J AF2     J D1                 7580200184
REFL WLNE                  6 0 0                                              7580200188
MARK EXCL                F 54.                                                7580200190
PLTE                   8I      .25                                            7580200192
PART     777-C3 S       N         4                                           7580200200
SEAM          TRGL       J AF2       J C       J AFI     J D1                 7580200204
PSTK                                                   2 0                    7580200208
REFL WLNE                  6 0 0                                              7580200212
MARK EXCL                F 67.                                                7580200214
PLTE                   8I      .25                                            7580200216
INPE                                                                          7580209999
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

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                             INPUT IS EXECUTABLE
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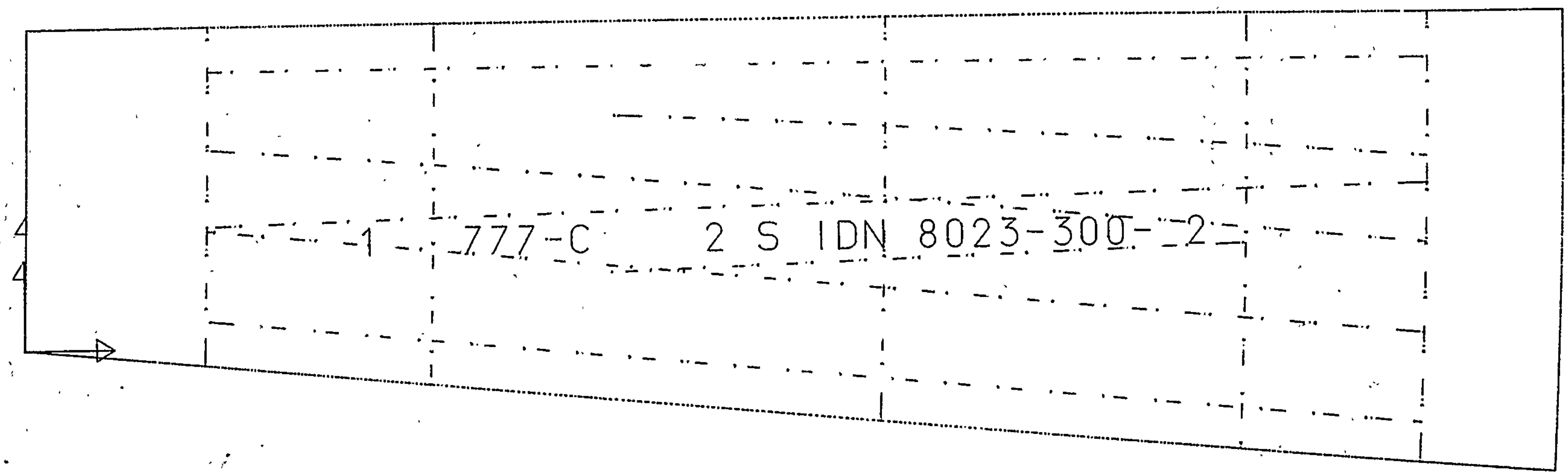
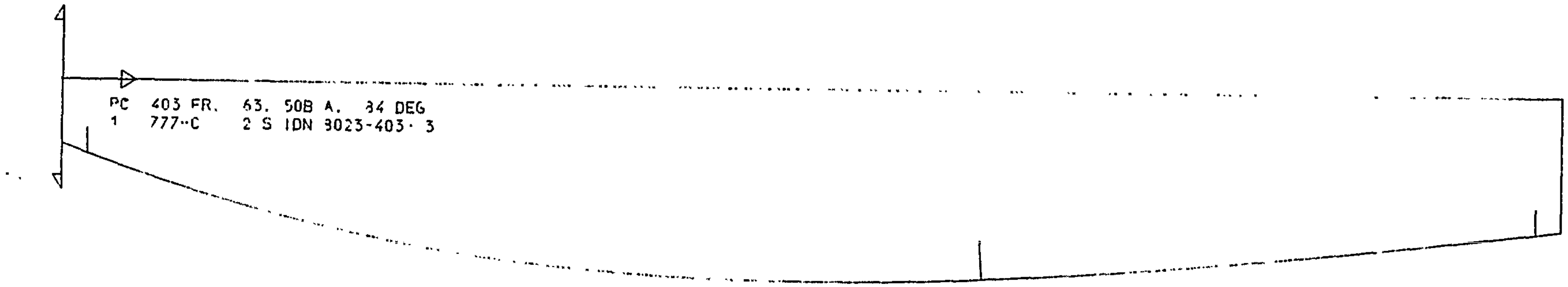
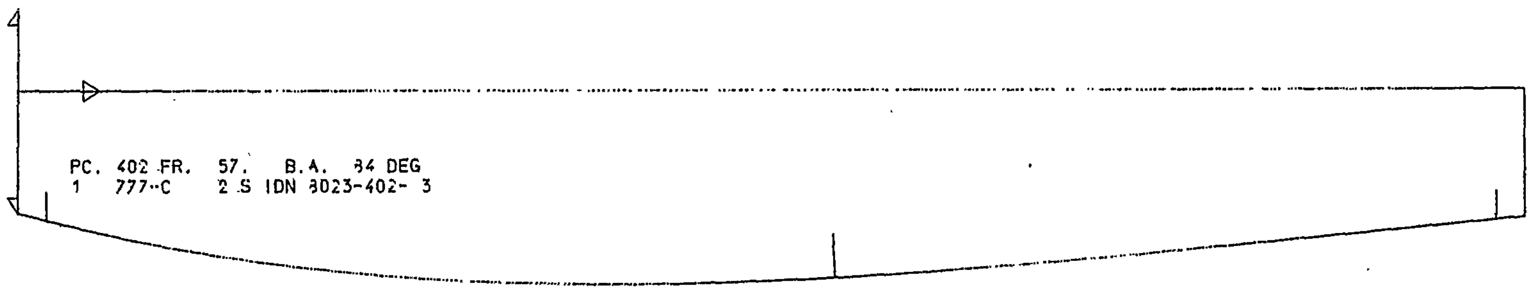
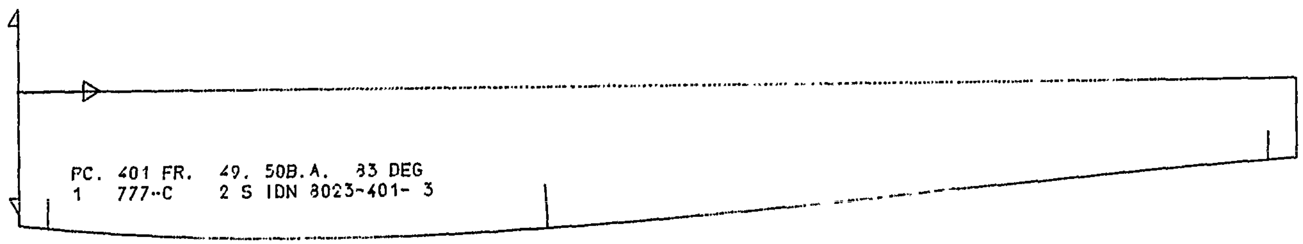


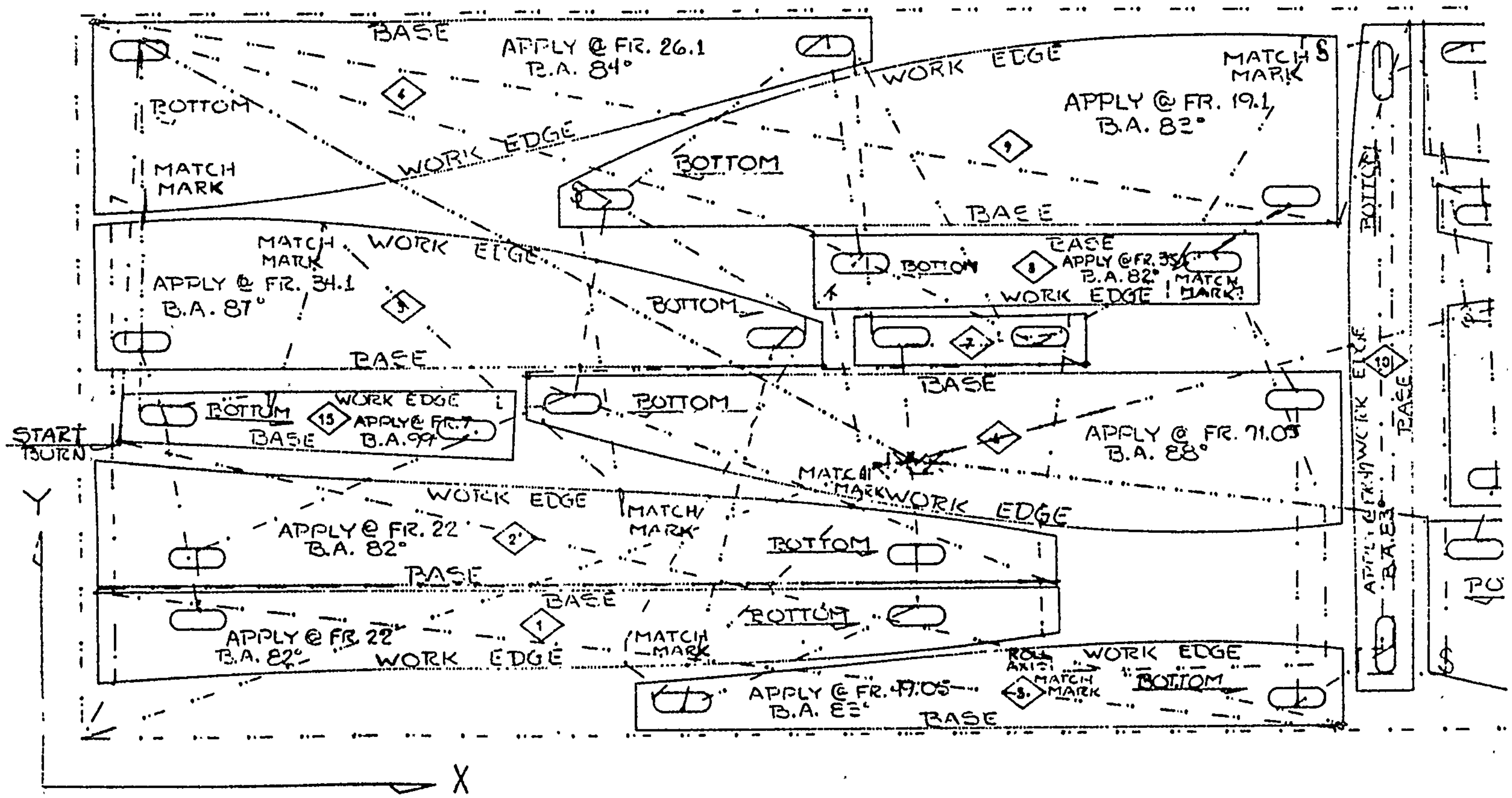
262

TAPE NO. 758023-300- 2


PC 403 FR. 63. 50B A. 84 DEG
1 777-C 2 S IDN 8023-403- 3


PC. 402 FR. 57. B.A. 84 DEG
1 777-C 2 S IDN 8023-402- 3


PC. 401 FR. 49. 50B.A. 83 DEG
1 777-C 2 S IDN 8023-401- 3



TAPE NO. 741011 - 2

PETERSON BUILDERS INC.

PGG 511 CLASS GUNBOAT

NO.PLATES LIKEWISE = 1 NO.PLATES MIRROR IMAGE= 0 TOTAL NO. PLATES = 1

PLATE SIZE = 14400X 4800X 25 STOCK NO.= MIL.= AL. 5456

PART TEMPLATES NESTED THIS TAPE

	PART NO.		QTY.		PART NO.		QTY.		PART NO.		QTY.
1	777-B	1 P	1	1	777-B	1 S	1	1	777-A	2 S	1
1	777-B	2 S	1	1	777-C	2 S	1	1	777-B	3 S	1
1	777-C	1 S	1	1	777-C	1 S	1	1	777-A	1 P	1
1	777-C	1 S	1	1	777-P	2 S	1	1	777-B	2 S	1
1	777-A	1 P	1	1	777-A	1 P	1	1	777-B	1AP	1

REVISIONS

REV	DESCRIPTION	BY	DATE

PREPARED BY

CALI & ASSOCIATES, INC.

CHECKED BY: VALIDATED BY:

JOB NO.7005PB01 NEST TAPE NO. 741011- 2 /

S P A D E S   S Y S T E M

DATE 06/12/76

IDENTIFICATION & PLOT LOCATION OF PARTS
FOR TAPE NO. 741011- 2

PLOT REF.	DRWG. & LOC.		N/C ID & MODE			LIKE PLATE MODULE & PCMK.			MIRR. PLATE MODULE & PCMK.
1	777	4-A	8031-403-	3	L	1	777-B	1 P	
2	777	4-A	8041-403-	3	L	1	777-B	1 S	
3	777	4-B	8011-402-	3	L	1	777-A	2 S	
4	777	4-B	8012-401-	3	L	1	777-B	2 S	
5	777	5-B	8023-401-	3	L	1	777-C	2 S	
6	777	5-B	8022-403-	3	L	1	777-B	3 S	
7	777	4-B	8013-401-	3	L	1	777-C	1 S	
8	777	4-B	8013-402-	3	L	1	777-C	1 S	
9	777	9-B	8071-403-	1	L	1	777-A	1 P	
10	777	4-B	8013-403-	3	L	1	777-C	1 S	
11	777	4-B	8012-403-	3	L	1	777-B	2 S	
12	777	4-B	8012-402-	3	L	1	777-B	2 S	
13	777	9-B	8071-401-	1	L	1	777-A	1 P	
14	777	9-B	8071-402-	1	L	1	777-A	1 P	
15	777	9-B	8102-403-	1	L	1	777-B	1AP	

*****

PIECES PRODUCED THROUGH N/C CUTTING

LINE-REV	PIECE MARK	DRAWING NO.	LOC.	QTY.	WGT.	MAT.	THK.	STK	N/C ID.	NEST TAPES	TEMPLATES	PROCESS 1ST 2ND	DESCRIPTION
21- 13	777-C 2 S	777	5-B	1	257	8	.25		8023-300- 2	10045- 3	8023-401- 3 8023-402- 3 8023-403- 3		SHELLPLTG FR.47
22- 13	777-C 3 P	777	5-B	1	150	8	.25	A	8024-300- 2M	10045- 3	8024-401- 1 8024-402- 1 8024-403- 1		SHELLPLTG FR.65
23- 13	777-C 3 S	777	5-B	1	150	8	.25	A	8024-300- 2	10045- 3	8024-401- 3 8024-402- 3 8024-403- 3		SHELLPLTG FR.65
24- 13	777-FK 1 C	777	5-A	1	173	8	.50		8061-300- 4	10046- 2			FLATKEEL FR.22
25- 13	777-FK 2 C	777	5-A	1	173	8	.50	A	8062-300- 3	10046- 2			FLATKEEL FR.47
26- 12	782 120001 C	782	4-A	1	18	8	.50		0160- 1- 3	0160- 1- 1			BRKT.PLT. FR.12
27- 13	782 520006 P	782	3-E	1	44	8	.44		0163- 1- 3	10038- 3			BKT.PLT.FR.51
28- 13	782 520006 S	782	3-E	1	44	8	.44		0163- 1- 3M	10038- 3			BKT.PLT.FR.51
29- 12	782 570037 P	782	3-C	1	1	8	.75		0164- 1- 1	0164- 1- 1			CHOCK PLT FR.57
30- 13	782 570037 S	782	3-C	1	1	8	.75		0164- 1- 1L		0164- 1- 1		CHOCK PLT FR.57
31- 12	783 231001 P	783	3A	1	1	8	.25		0065- 1- 3	10007- 5			INTC.FR. FR.23.1
32- 12	783 231001 S	783	3A	1	1	8	.25		0065- 1- 3M	10007- 5			INTC.FR. FR.23.1
33- 12	783 231002 P	783	3A	1	5	8	.25		0066- 1- 1	10007- 5			INCL.PCS.2-9
34- 12	783 231002 S	783	3A	1	5	8	.25		0066- 1- 1M	10007- 5			INCL.PCS.2-9

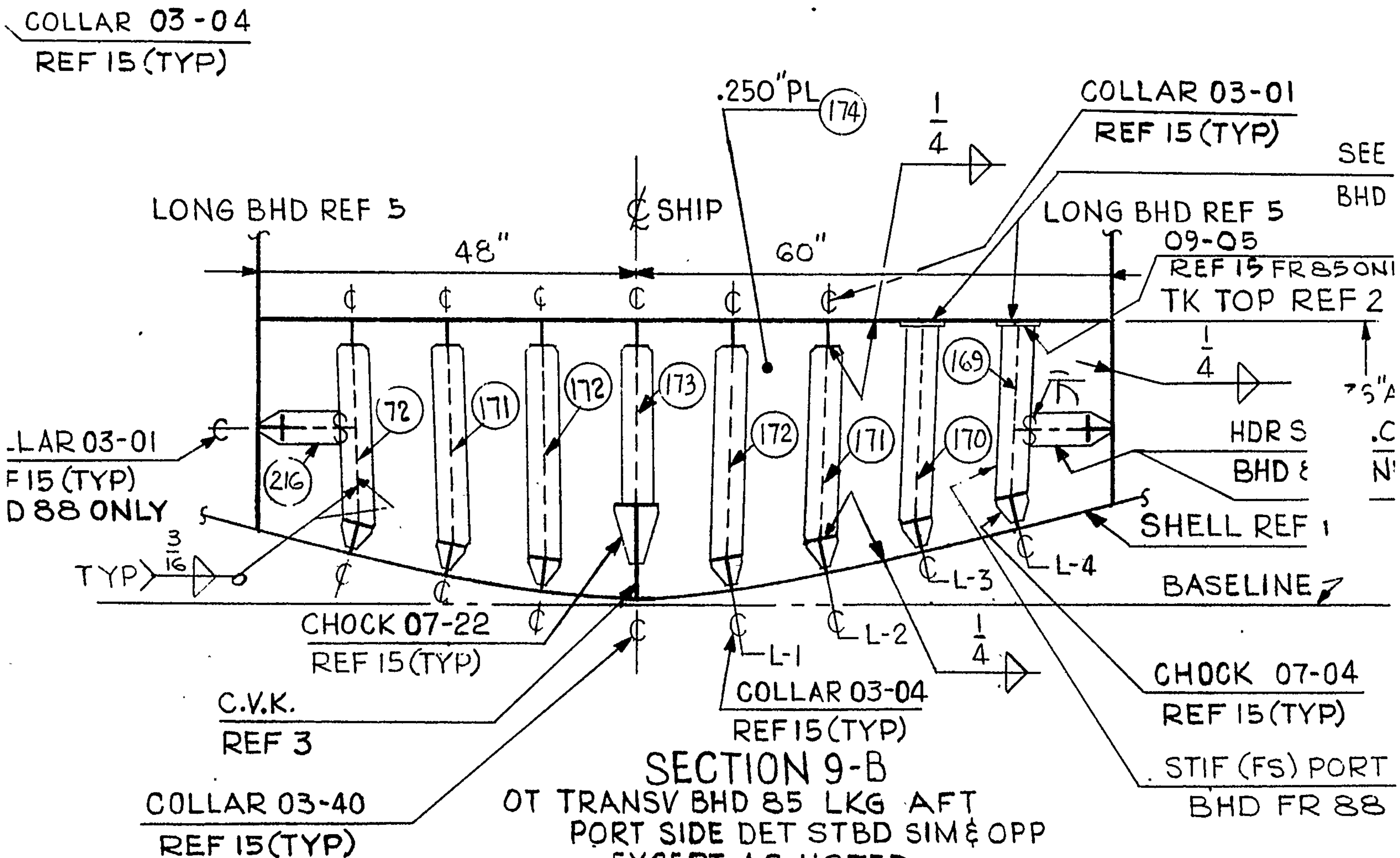
REPORT DATE : 06/15/78 S P A D E S S Y S T E M PAGE NO. 15. 4

D.B.NAME : PB01 7005PB01 SHIP PRODUCTION AND CONTROL MODULE MODULE/UNIT: 1

VESSEL : GUNBOAT (PPG 1) REPORT REV. 16

LIST OF TEMPLATES REQUIRED FOR PLATES

LINE	TEMPLATE	REST TAPE	PIECEMARKS	
52	8022-403- 1	741011	777-B	3 P
53	8022-403- 3	741011	777-B	3 S
54	8023-401- 1	741011	777-C	2 P
55	8023-401- 3	741011	777-C	2 S
56	8023-402- 1		777-C	2 P
57	8023-402- 3		777-C	2 S
58	8023-403- 1		777-C	2 P
59	8023-403- 3		777-C	2 S
60	8024-401- 1		777-C	3 P
61	8024-401- 3		777-C	3 S
62	8024-402- 1		777-C	3 P
63	8024-402- 3		777-C	3 S
64	8024-403- 1		777-C	3 P
65	8024-403- 3		777-C	3 S
66	8031-401- 3		777-B	1 P
67	8031-402- 3		777-B	1 P
68	8031-403- 3	741011	777-B	1 P



SECTION 9-B
OT TRANSV BHD 85 LKG AFT
PORT SIDE DET STBD SIM & OPP
EXCEPT AS NOTED
OT TRANSV BHD 88 SIM EXCEPT AS NOTED
ASSY SECTION NO.2

269

23

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         1         2         3         4         5         6         7         8
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INPUT UPDATING          DATE  05/02/78    TIME  21/05/47     RUN NO.    3
JOB P801  PROG. PART              INPUT 0052    REV. NO.   2        PAGE:  1

INPS                  N    0052                           625        7000520004
WRIT  JRP                                 A  90           1 0        7000520006
DRWG 786     9-B                                                     7000520008
MODL 2.07                                                            7000520012
TRSV             AFT    F 85000                                      7000520016
MOVE2                      6 0     6 0 0                             7000520020
ADDP                   DTT        PCRG                   -6 0    1   7000520024
LINE FAST             P       1                                      7000520028
PART 7860850174 C                                                    7000520032C
OUTP                                                                 7000520036
CNTR DOWN                                                            7000520040
LBHD             S-     LB4    S                                     7000520044
SHFT                         04           ANY-                       7000520048
                             04           ANY-                       7000520052
SAVE                                                         1       7000520056
LINK     NEW                                                         7000520060
LBHD             P+     LB5    P                                     7000520064
SHFT                         04           ANY+                       7000520068
                             04           ANY+                       7000520072
SAVE                                                         2       7000520076
LINK     NEW                                                         7000520080
DECK2                  DTT       SL1    P  PEND     S                7000520084
LINK     INT.                                                2       7000520088
CALL                                                         1       7000520092
LINK     INT EXTD                              6 0           3       7000520200
SHEL2                  M         LB4    S  LB5     P                 7000520204
LINK     INT     EXTD                                   6 0  4       7000520208
CALL                                                         2       7000520212
LINK     INT                                                 5       7000520216
DECK             P-     DTT                                          7000520220
CTRE                                                                 7000520224
CUTI                 YY       1                                      7000520226
PTNO                  P     300                                      7000520228
MIDN                   DTT                                           7000520232
RNGE                   SCL    C  SL3    S       4 0            *     7000520236
RATH2                 P       2S       08 A  45                      7000520240
STOL                        3 0                                      7000520244
MIDN                   LB4    S                                      7000520248
CCUT                   SL2    S       4 0 A*                  *4     7000520252
CCUT                   SL2    S           A*                  1011   7000520256
RNGE                   DTT    S  PCRG   S       4 0           *4     7000520260
RATH2                 P       3S       08 A -45                      7000520264
MIDN                   M                                             7000520268
RNGE                   SL3    S  SL4B   P       4 0           *5     7000520272
RATH2                 P       4S       08 A  45                      7000520276
MIDN                   LB5    P                                      7000520280
PTNO                  P     310                                      7000520284
CCUT                   SL2    P       4 0 A*                  *3     7000520288
                       SL2    P           A*                  1213   7000520292
RATH2                 P       5S       08 A -45                      7000520400
MIDN                   DTT                                           7000520404
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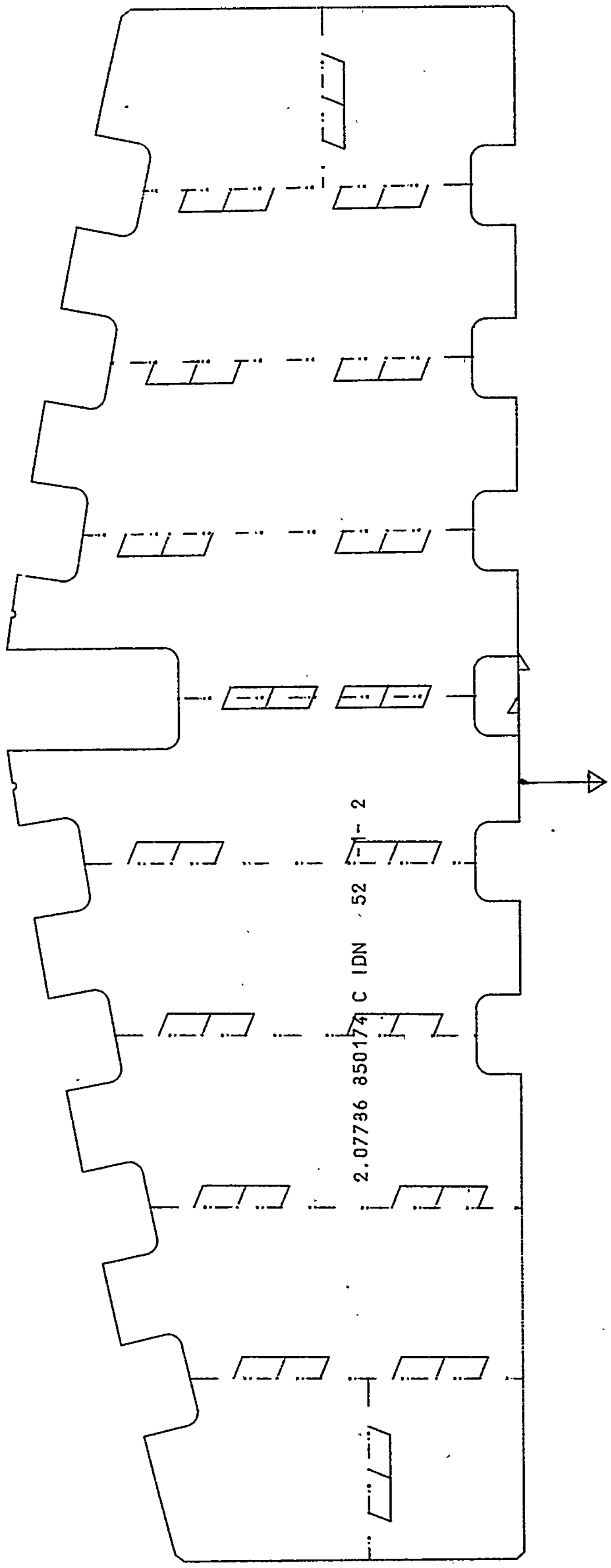
PART GEOMETRICAL DATA FOR NESTING REFERENCE   DATE 05/02/78   TIME 21/06/02
JOB 7005PR01   SHIP PB01   PART NO. 52 - 1 - 2   PAGE 1
TOOL-PC/K 2.07766 650174 C   DWG-LOC 786   9-8   REMARKS
MATERIAL CODE R   THICKNESS 0.250

DIMENSIONS IN DECF
SHRINKAGE FACTORS USED: X = 1.000000   Y = 1.001040
STARTING POINT OF PART X = 3.000   Y = -0.500

*****PIECE NESTED ON TAPE NUMBER(S) 10039

SEG. NO.	STARTING POINT X	Y	TYPE	VEL	KERF	MOVEMENT DX	WITH DY	CENTER LOCATION DXC	DYC	ROT
1	0.0	0.0	CUT	CT	R	0.0	0.271			
2	0.0	0.271	CUT	CT	R	-0.172	0.0			
3	-0.172	0.271	CUT	CT	R	-0.083	0.083	0.0	0.083	-
4	-0.255	0.355	CUT	CT	R	0.0	0.146			
5	-0.255	0.501	CUT	CT	R	0.0	0.146			
6	-0.255	0.647	CUT	CT	R	0.083	0.083	0.083	0.0	-
7	-0.172	0.730	CUT	CT	R	0.172	-0.000			
8	0.0	0.730	CUT	CT	R	0.0	0.496			
9	0.0	1.226	CUT	CT	R	-0.172	0.000			
10	-0.172	1.226	CUT	CT	R	-0.083	0.083	0.000	0.083	-
11	-0.255	1.310	CUT	CT	R	0.0	0.154			
12	-0.255	1.464	CUT	CT	R	0.0	0.138			
13	-0.255	1.602	CUT	CT	R	0.083	0.083	0.083	0.0	-
14	-0.172	1.685	CUT	CT	R	0.172	-0.000			
15	0.0	1.685	CUT	CT	R	0.0	0.539			
16	0.0	2.224	CUT	CT	R	-0.172	0.0			
17	-0.172	2.224	CUT	CT	R	-0.083	0.083	0.000	0.083	-
18	-0.255	2.308	CUT	CT	R	0.0	0.154			
19	-0.255	2.462	CUT	CT	R	0.0	0.138			
20	-0.255	2.600	CUT	CT	R	0.083	0.083	0.083	0.0	-
21	-0.172	2.683	CUT	CT	R	0.172	-0.000			
22	0.0	2.683	CUT	CT	R	0.0	0.539			
23	0.0	3.222	CUT	CT	R	-0.172	0.0			
24	-0.172	3.222	CUT	CT	R	-0.083	0.083	0.000	0.083	-
25	-0.255	3.306	CUT	CT	R	0.0	0.154			
26	-0.255	3.460	CUT	CT	R	0.0	0.138			
27	-0.255	3.598	CUT	CT	R	0.083	0.083	0.083	0.0	-
28	-0.172	3.681	CUT	CT	R	0.172	-0.000			
29	0.0	3.681	CUT	CT	R	0.0	0.761			
30	0.0	4.442	CUT	CT	R	-0.042	0.042			
31	-0.042	4.484	CUT	CT	R	-2.165	0.000			
32	-2.206	4.484	CUT	CT	R	-0.051	-0.041			
33	-2.258	4.443	CUT	CT	R	-0.069	-0.292	36.417	-8.692	+
34	-2.326	4.151	CUT	CT	R	-0.086	-0.390	40.820	-9.226	+
35	-2.412	3.761	CUT	CT	R	0.249	-0.052			
36	-2.163	3.709	CUT	CT	R	0.065	-0.099	-0.017	-0.082	-
37	-2.099	3.610	CUT	CT	R	-0.037	-0.176			
38	-2.136	3.434	CUT	CT	R	-0.040	-0.191			
39	-2.176	3.243	CUT	CT	R	-0.099	-0.065	-0.082	0.017	-
40	-2.274	3.178	CUT	CT	R	-0.249	0.052			
41	-2.523	3.231	CUT	CT	R	-0.092	-0.470	41.017	-8.306	+
42	-2.615	2.760	CUT	CT	R	0.250	-0.046			
43	-2.365	2.714	CUT	CT	R	0.067	-0.097	-0.015	-0.082	-
44	-2.299	2.617	CUT	CT	R	-0.032	-0.177			


2.07736 850174 C IDN 52

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INPUT UPDATING           DATE  05/17/78     TIME  08/52/41     RUN NO.    5
JOB PB01  PROG. PART  SPAC        INPUT 0053    REV. NO.    4        PAGE   1

INPS                   R     0053                                      7000530004
RMKS  JRP                                                              7000530008
DRNG 786       9-8                                                     7000530012
MODL 2.07                                                              7000530016
TRSV              AFT   F 85000                                        7000530020
ADDP                    DTT         SCL     C     - 3 0          20    7000530021
DBTP 7861730850 C       R           SLVR    C A*                       7000530024
              SWCTSGCT          S         1 8 R      904               7000530028
                       P      20                                       7000530032
                                                                1      7000530036C
DBTP 7861720850 S       R           SL1     S A*                       7000530040
                                S         1 8 R      904               7000530044
                        DTT         SL1     S A*                       7000530048
                                S         1 8                   2      7000530052
DBTP 7861710850 S       R           SL2       A*                       7000530056
                                S         1 8 R      904               7000530060
                        DTT         SL2       A*                       7000530064
                                S         1 8                   3      7000530068
DBTP 7860720850 S       R           SL3       A*                       7000530072
                                S         1 8 R      904               7000530076
                        DTT         SL3       A*                       7000530080
                                S         1 8                   4      7000530084
CNTR     CALC                                                          7000530260
DECK              P+    DTT                                            7000530270
CTRE                                                                   7000530280
MION                    DTT                                            7000530290
STOL                          06                                       7000530300
CCUT                    SL3   F         4 0 A*                   55    7000530310
CCUT                    S L3  F             A*                   50    7000530320
                        SL4A  F         4 0 A*                   54    7000530330
                        SL4A  F             A*                   51    7000530340
CUTE                                                                   7000530350
CNTR     CALC                                                          7000530360
SHEL              P+    R                                              7000530370
CTRE                                                                   7000530380
MION                    R                                              7000530390
DBCT                    SL3   F         4 0                      43    7000530400
                        SL3   F                                  40    7000530410
                        SL4B  F         4 0                      44    7000530420
                        SL4B  F                                  41    7000530430
CUTE                                                                   7000530440C
TMPL 7861700850 P      F     43                                        7000530450
     904               P     40                                        7000530460
                              S        1 8 ASL3     P  R               7000530470
                       P     53                                        7000530480
                       P     50                                        7000530490
         STORTAPE             S        1 8 ASL3     P  DTT        7    7000530500
TMPL 7861690850 P      P     44                                        7000530510
     904               P     41                                        7000530520
                              S        1 8 ASL4B    P  R               7000530530
                       P     54                                        7000530540
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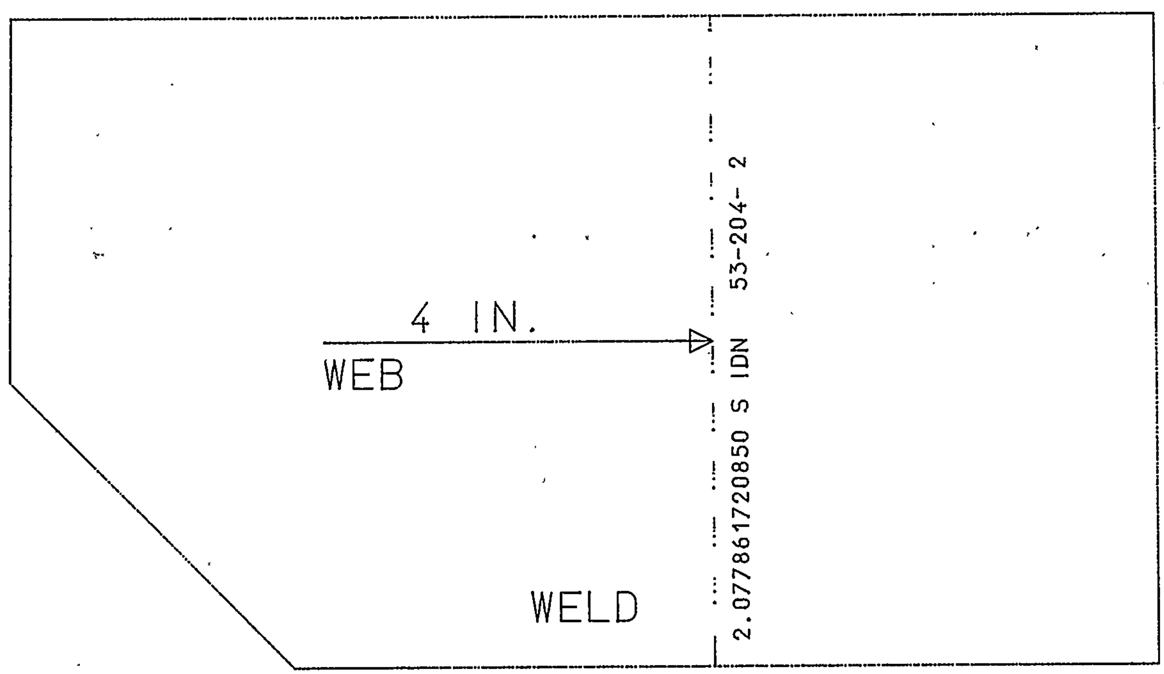

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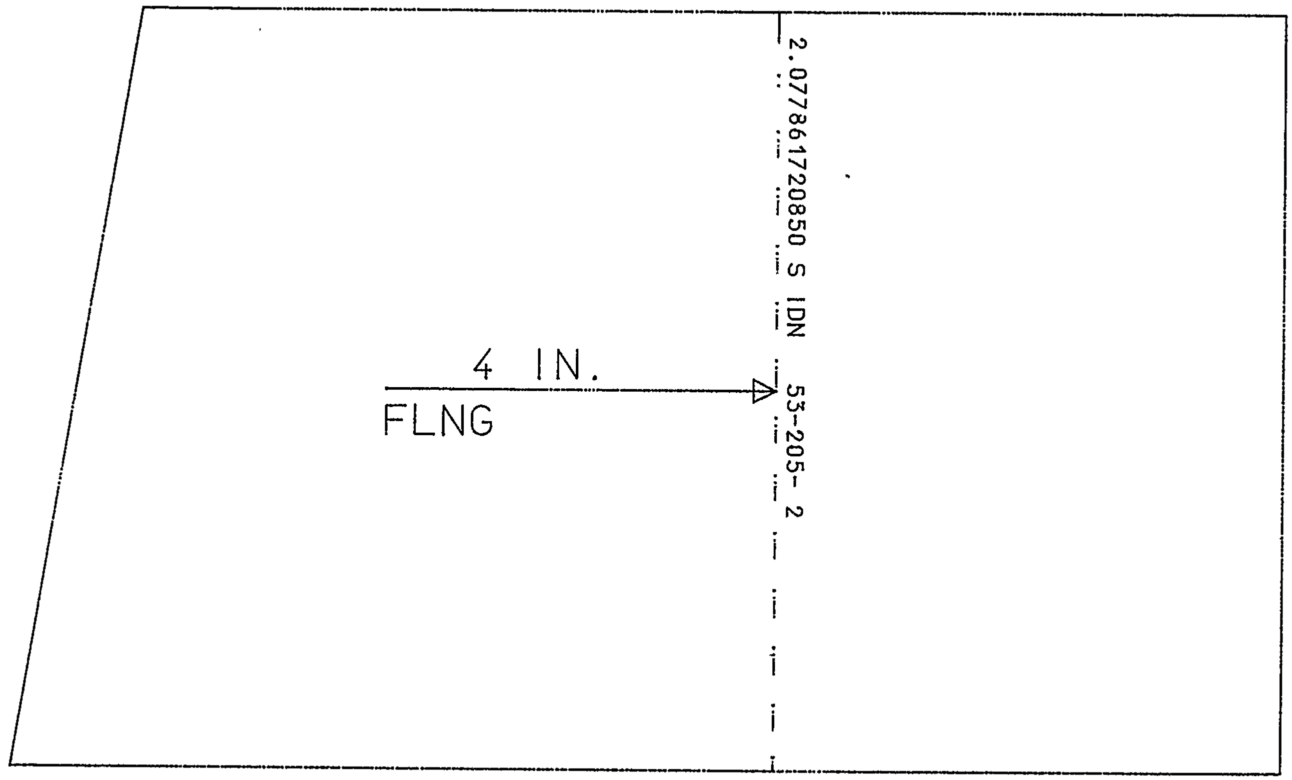

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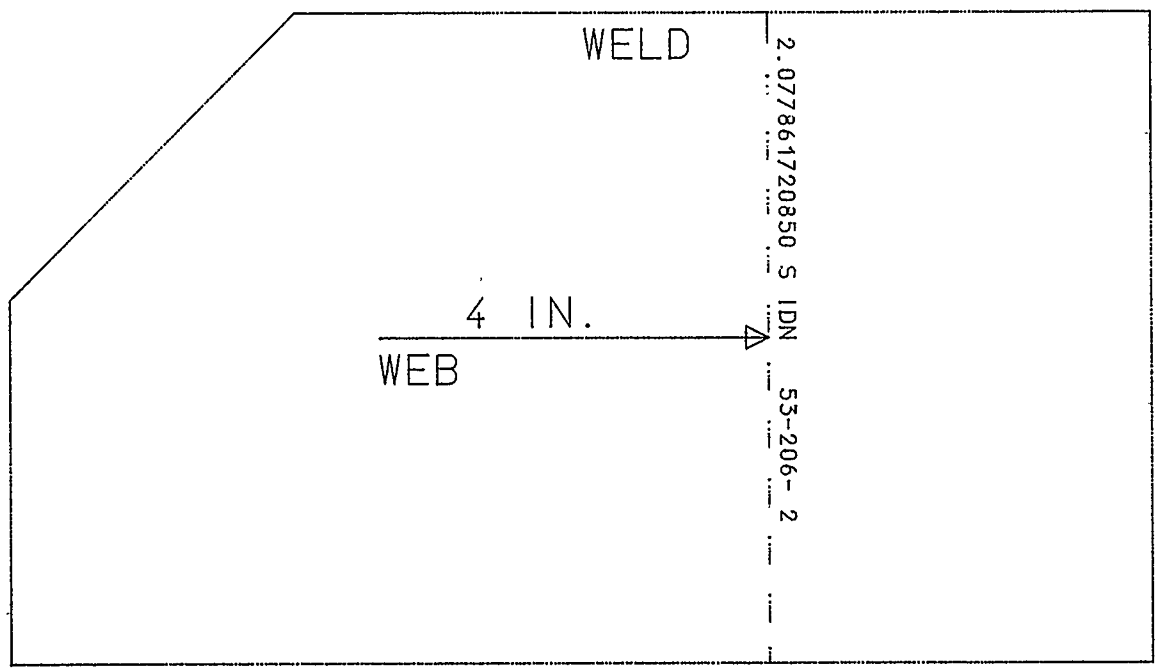
TAPE NO. 780053-205- 2

29



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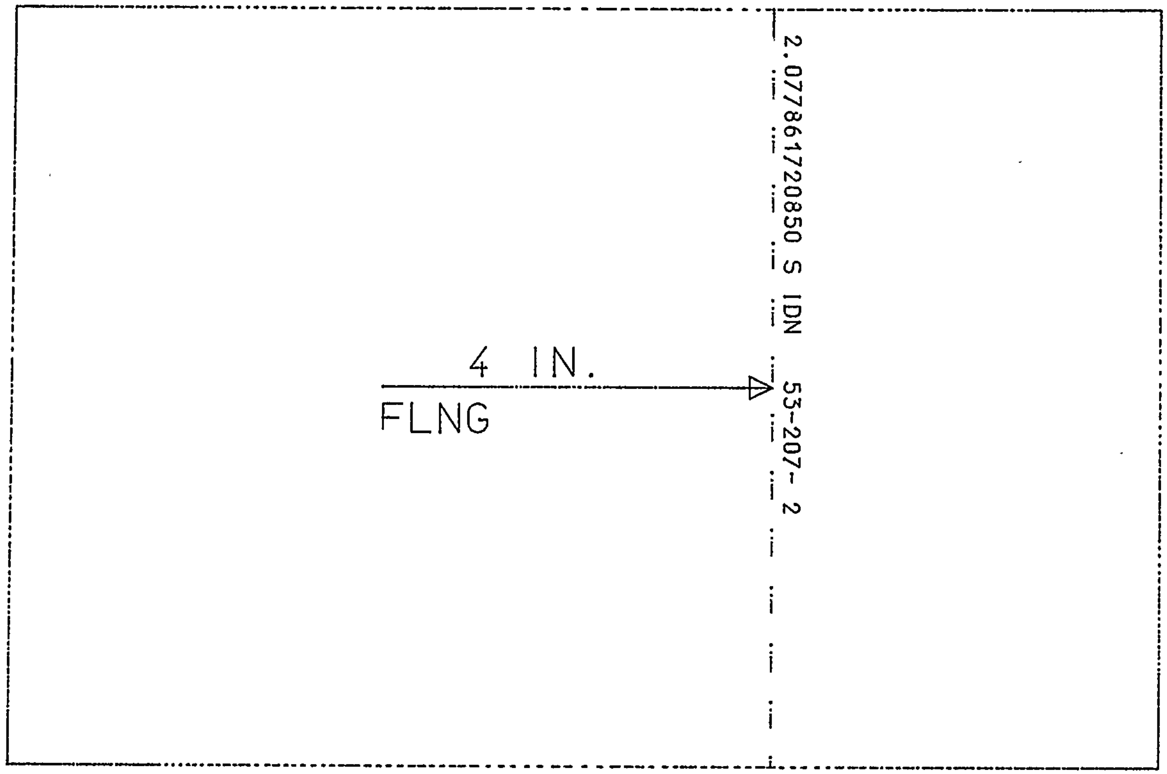

TAPE NO. 780053-207- 2

PIECES PRODUCED FROM SHAPES

LINE-REV	PIECE MARK/ DRAWING NO.	QTY/ LOC.	WGT.	MAT'L	LENGTH	STK	'A'	'B'	'C'	N/C ID	WEB 1 FLANGE 1	WEB 2 FLANGE 2	OTHER N/C AIDS
12- 3	7861700850 P 786	1 9-B	4	8S 904	2-01-12		1-05-12	4	4	0	B0053-216- 4 0053-217- 4	T0053-218- 4 0053-219- 4	0 0 BHD.STIFF. FR.85
13- 6	7861710850 P 786	1 9-B	4	8S 904	2-01-06		1-05-06	4	4	0	L B0053-208- 2 0053-209- 2	T0053-210- 2 0053-211- 2	0 0 BHD.STIFF. FR.85
14- 3	7861710850 S 786	1 9-B	4	8S 904	2-01-06		1-05-06	4	4	0	B0053-206- 2 0053-209- 2	T0053-210- 2 0053-211- 2	0 0 BHD.STIFF. FR.85
15- 3	7861710861 P 786	1 9-B	4	8S 904	2-01-11		1-05-11	4	4	0	B0353-206- 1 0353-209- 1	T0353-210- 1 0353-211- 1	0 0 BHD.STIF.FR.86.1
16- 6	7861710861 S 786	1 9-B	4	8S 904	2-01-11		1-05-11	4	4	0	L B0353-208- 1 0353-209- 1	T0353-210- 1 0353-211- 1	0 0 BHD.STIF.FR.86.1
17- 3	7861710880 P 786	1 9-B	4	8S 904	2-01-13		1-05-13	4	4	0000- 0- 1M	B0354-208- 1 0354-209- 1	T0354-210- 1 0354-211- 1	0 0 BHD.STIFF. FR.88
18- 3	7861710880 S 786	1 9-B	4	8S 904	2-01-13		1-05-13	4	4	0	B0354-208- 1 0354-209- 1	T0354-210- 1 0354-211- 1	0 0 BHD.STIFF. FR.88
19- 6	7861720850 P 786	1 9-B	5	8S 904	2-03-06		1-07-06	4	4	0	L B0053-204- 2 0053-205- 2	T0053-206- 2 0053-207- 2	0 0 BHD.STIFF. FR.85
20- 3	7861720850 S 786	1 9-B	5	8S 904	2-03-06		1-07-06	4	4	0	B0053-204- 2 0053-205- 2	T0053-206- 2 0053-207- 2	0 0 BHD.STIFF. FR.85
21- 3	7861720861 P 786	1 9-B	5	8S 904	2-03-10		1-07-10	4	4	0	B0353-204- 1 0353-205- 1	T0353-206- 1 0353-207- 1	0 0 BHD.STIF.FR.86.1
22- 6	7861720861 S 786	1 9-B	5	8S 904	2-03-10		1-07-10	4	4	0	L B0353-204- 1 0353-205- 1	T0353-206- 1 0353-207- 1	0 0 BHD.STIF.FR.86.1

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INPUT UPDATING          DATE  05/29/78    TIME  08/59/54     RUN NO.    4
JOB P801  PROG. NEST              INPUT 0039    REV. NO.   3        PAGE   1

INPS STORTAPEDECF2-AX N      39                                      7100390104
PSPR ESIIPLSMEVEN    PN      1KN       1                             7100390108
RMKS D.N.                                                            7100390112
PLTE                 8H      4              22.5   1  84.         1  7100390116
PIEC ABSL              0130   1         4         6                  7100390120
                           .1        .05  A  90.                     7100390124
    2                  0350   1         3        30                  7100390128
    2                  0130   1                   2                  7100390132
    2                      .14            A -90.                     7100390136
    2                  0351   1         2        106                 7100390140
    2                  0350   1                  99                  7100390144
    2                      .17            A -90.                     7100390148
PIEC ABSL              0375   2         2         2         5        7100390152
     1521130005 P2.08    20.49   .35     20.49      2.25             7100390156C
REPT ABSL            M 0375   99                  5         2        7100390160
     1521130005 S2.08    20.45  2.4      22.4       2.4              7100390164
PIEC ABSL              0376   2         1         5         2        7100390168
     1521210005 F2.08    22.42   .2      22.42      2.16             7100390172
REPT ABSL            M 0376   88                  2         5        7100390176
     1521210005 S2.08    20.47   .05     22.4       .05              7100390180
PIEC ABSL              0130   2         2         2                  7100390184
                         2.4    5.3   A 180.                         7100390185
PIEC2                  0052   1         2        31                  7100390188
    2                  0130   2                   3                  7100390192
    2                      .1        .199 A  90.                     7100390196
OPTN DIST             H                                              7100390200
DIST                   0130   1         5         6                  7100390204
MARK CKPT                16.    1.5                                  7100390208C
AUTO                                                                 7100390212
OUTC CKPT                                                            7100390216
BURN TCUP    RVRS      0375   2     1   2      .04       .02         7100390220
             RVRS      0351   1    30  31      .04       .02         7100390226
             RVRS      0376   2     3   4      .04       .02         7100390232
                       0375   99    4   3      .04       .02         7100390236
                       0376   88    2   1      .04       .02         7100390240
                       0350   1    99  98      .04       .02         7100390244
             RVRS      0130   1     1   2      .04       .02         7100390248
                       0130   2     6   5      .04       .02         7100390252
             RVRS      0052   1    30  31      .04       .02         7100390256
INPE CKPT                                                            7100399999
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           SEVERITY = 0    INPUT IS STORED WITH REV. =    4

                      INPUT IS EXECUTABLE
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*                                                                            *
* PLATE SIZE = 27000X 8400X 25 STOCK NO.=                  MTL.= AL. 5086 *
*                                                                            *
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*                                                                            *
*    PART NO.        QTY.       PART NO.        QTY.      PART NO.      QTY. *
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*  2.081521130005 P   1      2.081521130005 S    1      2.081521210005 P   1 *
*  2.081521210005 S   1      2.077861010177 P    1      2.07786 850174 C   1 *
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*            C A L I   &   A S S O C I A T E S ,   I N C .                   *
*       ----------------------------------------------------------           *
* CHECKED BY:                              VALIDATED BY:                     *
******************************************************************************
* JOB NO.7005PB01                      NEST TAPE NO.     710039- 2   /        *
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S P A D E S   S Y S T E M DATE 05/29/78

IDENTIFICATION & PLOT LOCATION OF PARTS
FOR TAPE NO. 710039- 2

PLOT REF.	DRWG. & LOC.	N/C ID & MODE	LIKE PLATE MODULE & PCMK.	MIRR. PLATE MODULE & PCMK.
1	786	0130- 1- 4 L	2.077861010189 S	
2	786 9-A	0350- 1- 3 L	2.07786 861174 C	
3	786 9-B	0351- 1- 2 L	2.07786 880174 C	
4	152 7A	0375- 2- 2 L	2.081521130005 P	
5		M	2.081521130005 S	
6	152 9A	0376- 2- 1 L	2.081521210005 P	
7		M	2.081521210005 S	
8	786	0130- 2- 2 L	2.077861010177 P	
9	786 9-B	0052- 1- 2 L	2.07786 850174 C	

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S P A D E S   S Y S T E M                    DATE  05/29/78

     SUMMARY REPORT OF BURNING TAPE NO.        710039 -  2

PIERCING TIME             0.9   (PIERCING ALLOWANCE 0.1/ 0.1 MIN.)

RAPID TRAVERSE TIME       7.1   (ASSUMED SPEED  20.00  FT./MIN.)

CENTER PUNCHING TIME      3.2   (ASSUMED SPEED  20.00  FT./MIN.)

BURNING TIME             11.2   (ASSUMED SPEED  12.50  FT./MIN.)

TOTAL PROCESSING TIME      22.4  MINUTES

POST PROCESSOR OPTIONS USED FOR TAPE :

FORMAT : ESI1

CUTTING PROCESS : PLSM

PAPER TAPE PARITY : EVEN

PLATE OUTLINED BY : B.M.

KERF COMPENSATED BY GEOMETRY

                  MATERIAL UTILIZATION DATA

                PLATE UTILIZATION =    53.0 PERCENT

                SCRAP WEIGHT      =   255.8 POUNDS

                TYPE OF MATERIAL  AL. 5086

NO ERRORS DETECTED IN THIS RUN

PAPER TAPE IMAGE HAS BEEN STORED IN THE DATABASE

PAPER TAPE IMAGE EXISTS IN THE D.B. UNDER REV.  2 - STATUS = 0.
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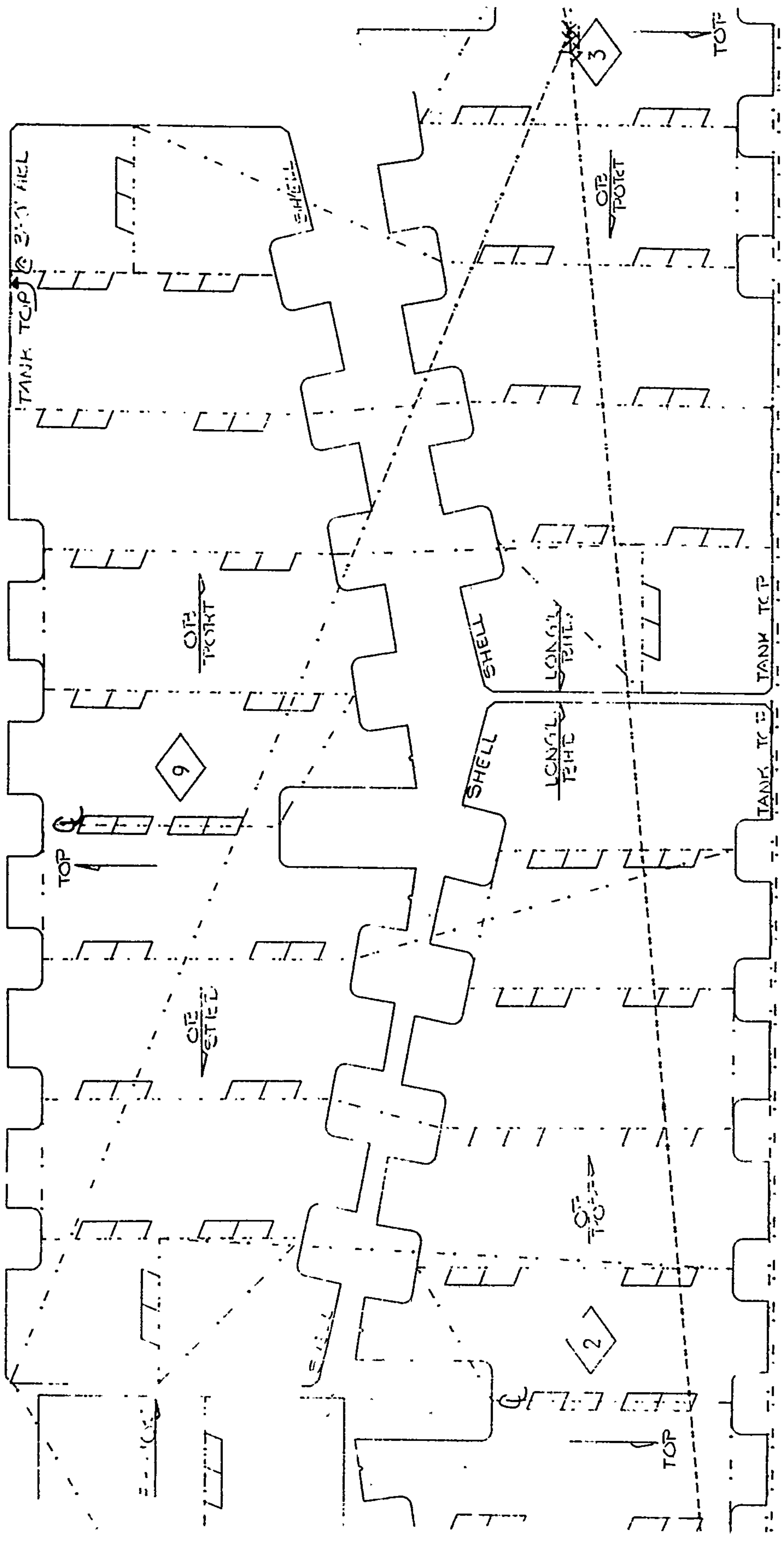
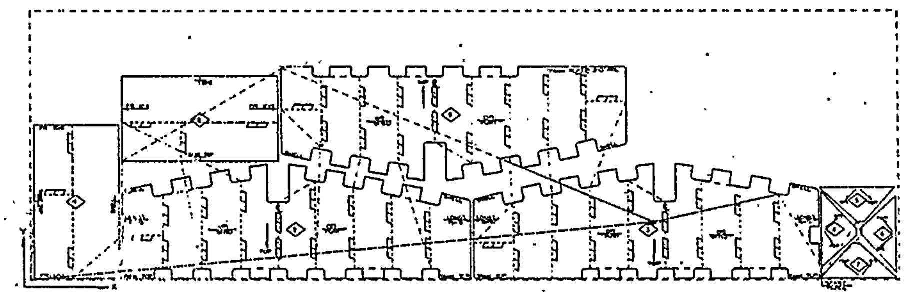

3
TOP
OB PORT
TANK TOP
SHELL
LONG'L BHD
9
OB STBD
2

284



TAPE NO. [illegible]039 - 2

REPORT DATE : 06/14/79 S P A D E S S Y S T E M PAGE NO. 6. 1

D.B.NAME : P001 7005PB01 SHIP PRODUCTION AND CONTROL MODULE MODULE/UNIT: 2.07

VESSEL : GUNBOAT (PFG 1) REPORT REV. 6

PLATE MATERIAL LIST

LINE	STOCK NO.	GRADE	SIZE	QTY.	N/C-TAPE NO.	PRC.TIME	LOC.	NOTES:
1		AL. 5086	27000X 8400X 25	1	710039- 2	22.4		
2		AL. 5086	28600X 6000X 25	1	710049- 2	20.7		

TOTAL PLATE WEIGHT 958.6 LBS

TOTAL SCRAP WEIGHT 395.7 LBS

REPORT DATE : 06/14/78 S P A D E S S Y S T E M PAGE NO. 7. 1

D.B.NAME : P801 7005P801 SHIP PRODUCTION AND CONTROL MODULE MODULE/UNIT: 2.07

VESSEL : GUNBOAT (PPG 1) REPORT REV. 6

PIECES PRODUCED THROUGH N/C CUTTING

LINE-REV	PIECE MARK	DRAWING NO.	LOC.	QTY.	WGT.	MAT.	THK.	STK	N/C ID.	NEST TAPES	TEMPLATES	PROCESS 1ST 2ND	DESCRIPTION
1- 4	786 850174 C	786	9-B	1	71	8	.25		0052- 1- 2	10039- 2			BHD.PLTNG.FR.85
2- 4	786 861174 C	786	9-A	1	71	8	.25		0350- 1- 3	10039- 2			BHD.PLTG.FR.86.1
3- 4	786 880174 C	786	9-B	1	72	8	.25		0351- 1- 2	10039- 2			BHD.PLTNG. FR.88
4- 4	7861010177 P	786		0	30	8	.25		0130- 2- 2	10039- 2			
5- 4	7861010189 S	786		0	30	8	.25		0130- 1- 4	10039- 2			
6- 6	7861050146 P	786		0	2	8	.25		0139- 1- 2				
7- 6	7861050178 C	786	10-C	1	172	8	.25		0127- 1- 3	10049- 2			BHD.PLTNG.FR.105

IMPROVED SHIPYARD CONTROL WITH TOMAS (TOTAL MANAGEMENT SYSTEM)

Antonio Manchinu
Shipping Research Services, Inc.
Alexandria, Virginia

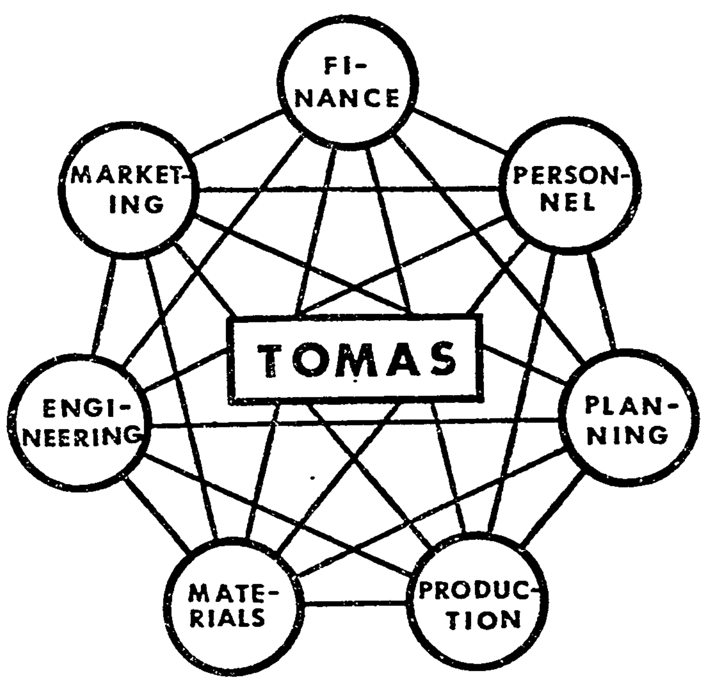
Mr. Manchinu is Vice President of SRS, Inc. In the past he managed the Management and Control Section of SRS A/S in Norway; served as project leader for studies of shipyard modernization, cost estimation, construction scheduling, and planning; and worked as a production engineer. He has a B.SC. degree in industrial engineering and economics from the Horten Institute of Technology in Norway.

ToMaS

"ToMaS" - AUTOMATING THE CONSULTANT'S TASK?

"Automation.....it is not a nightmare of push-button machines and soul destroying anonymity. It is, rather, a conception of how work should be organized."

Roger Falk
The Business of Management



(1.)

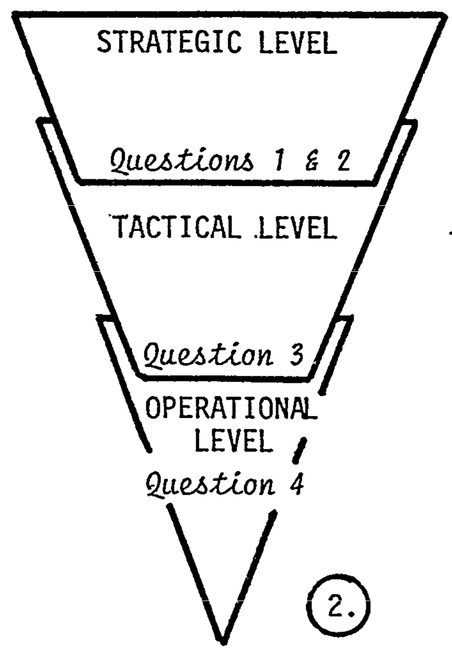
1. PREAMBLE

In common with any business enterprise, the tasks of management in a shipyard may be specified within three levels:

1. The strategic level - to establish objectives for the shipyard.

2. The tactical level - to translate the shipyard's objectives into plans, schedules and budgets.

3. The operational level - to coordinate and control the shipyard's operations against plans, schedules and budgets.



For objective management to be of benefit to the shipyard, there must be continual and critical review and modification of the shipyard's strategy and tactics, the questions which need to be answered being:

1. Knowing the external environment and the shipyard's past performances, what are the realistic alternative strategies?

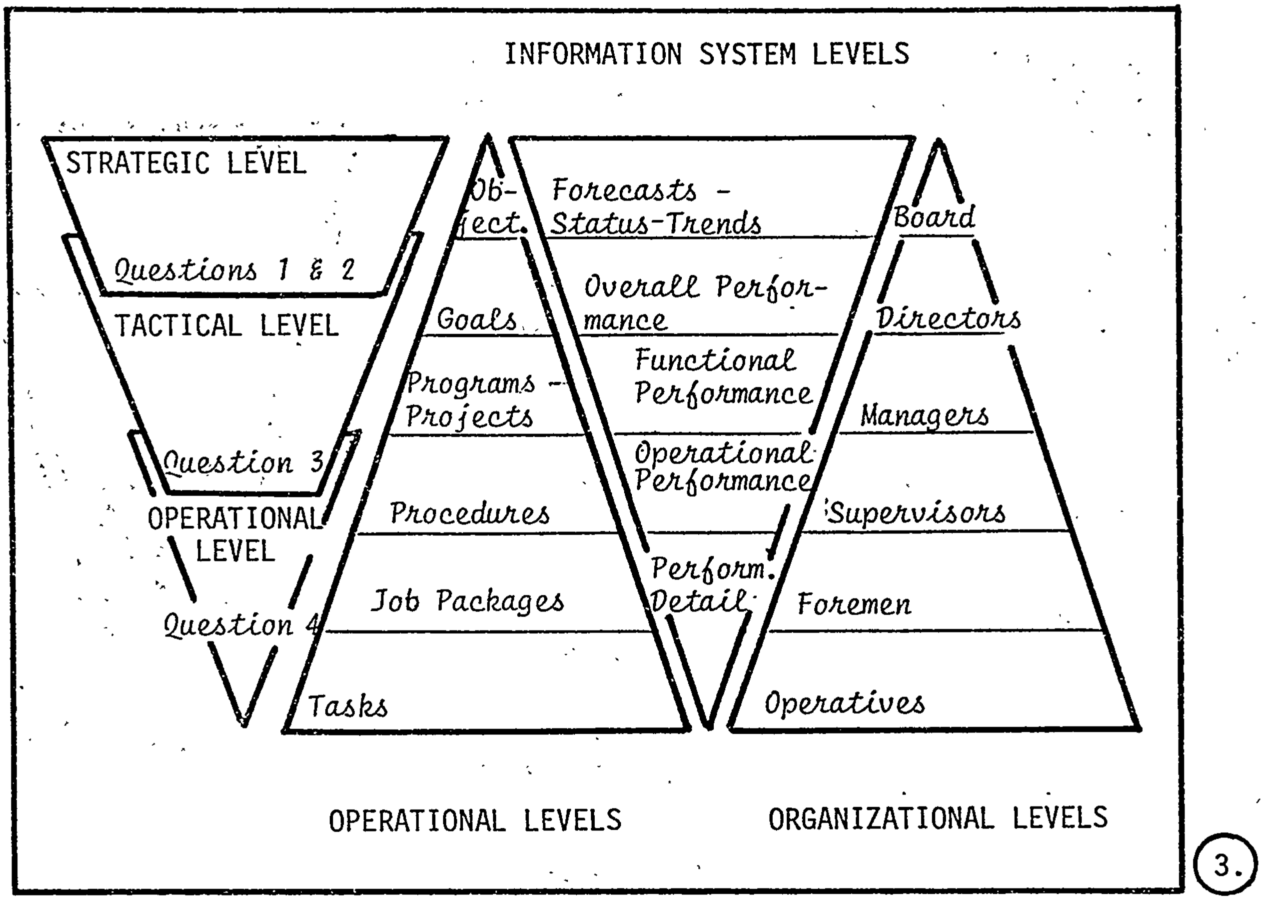
2. Which of these alternative strategies provides the best achievable goal for the shipyard?

3. What is the most cost effective application of the shipyard's resources to achieve this goal?

4. How can we organize the work content at the operational level within this application of the shipyard's resources?

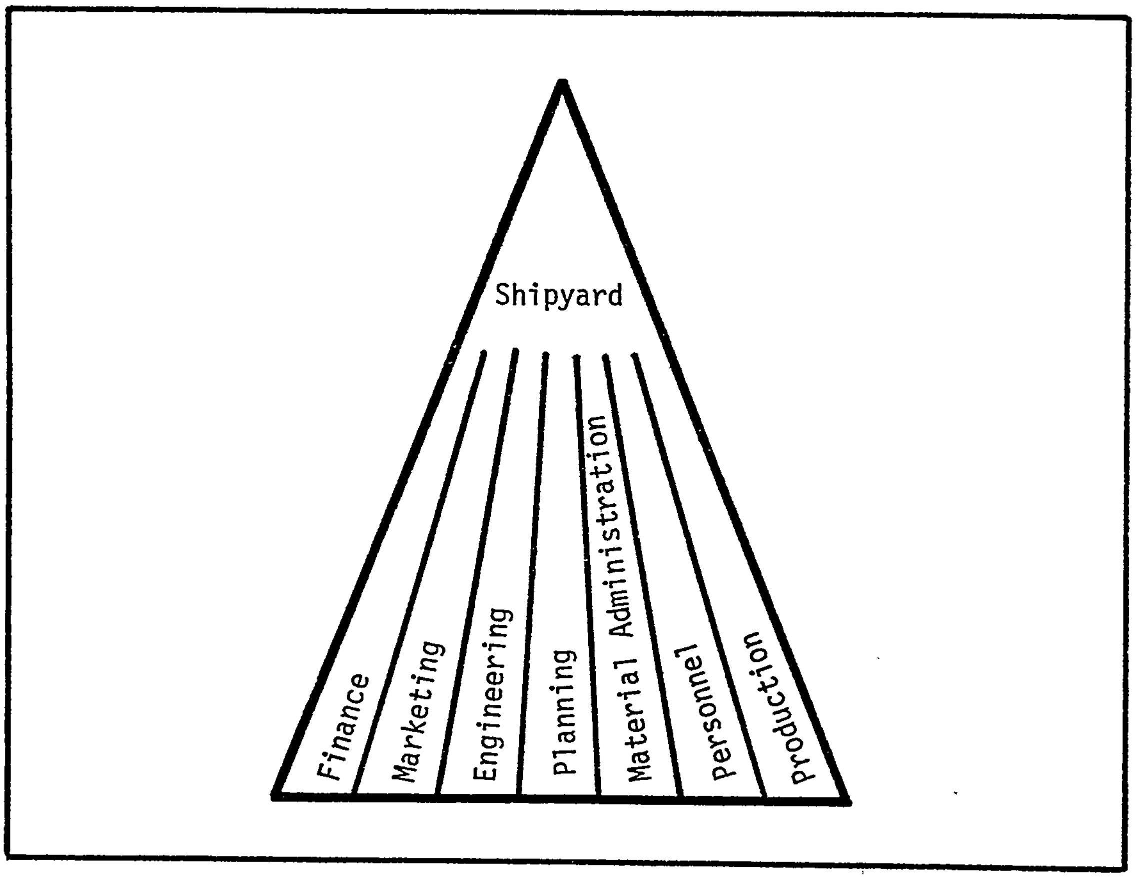
This concept of objective management with its three levels, in general dictates the transverse levels in a shipyard's organizational structure and since we have concluded that continual and critical review and modification of strategy and tactic is essential we further conclude that the organizational structure must be fluid, that is a cost effective shipyard at any time will be organized to achieve its current objectives.

The integration of a shipyard's organizational levels with its management and operation can be demonstrated diagrammatically, the questions referenced on the diagram being the four questions introduced above:



The objective management task of answering these four questions is dependent on the availability of information in the correct form at each level. We can, therefore, conclude further that the systematic flow of information, both transversely and vertically within the organizational structure is essential to the operation of the shipyard within the defined objectives.

Whilst organizational structure will vary from shipyard to shipyard as a result of each yard's individual objectives and will vary within each yard with changing objectives over time, certain basic functions can be identified which remain relatively static and which have relatively static information requirements. These basic functions are presented diagrammatically below.



4.

2. WHAT IS ToMaS?

ToMaS (Total Management System)IS A SHIPYARD MANAGEMENT MODEL THAT HAS BEEN DEVELOPED FROM A-DETAILED ANALYSIS OF THE INTEGRAL FUNCTIONS OF A SHIPYARD .

Background

As consultants working with administrative/organizational routines and administrative data processing within the shipbuilding industry, SRS has seen the need for a systematic analysis of the functions and information systems in the shipyard.

This is why the ToMaS project was. initiated.

ToMaS is now an unique detailed refetience “tool” for administrative control in the shipyard.

Goals of the ToMaS Project

Phase 1:

To analyze and describe the functions-and the information systems of a shipyard, i.e.,

- flow of information and goods between the shipyard and its environment (authorities, suppliers, etc.)
- flow of information and goodsbetween the functions of the yard
- information processing within the functions.

We made the results of the analyses "general, " i.e., independent of any particular organization structure.

To obtain this we considered the shipyard as consisting of functions rather than organizational departments.

The material from this phase is an useful reference framework for studying administrative routines and finding information processing alternatives (manual/EDP).

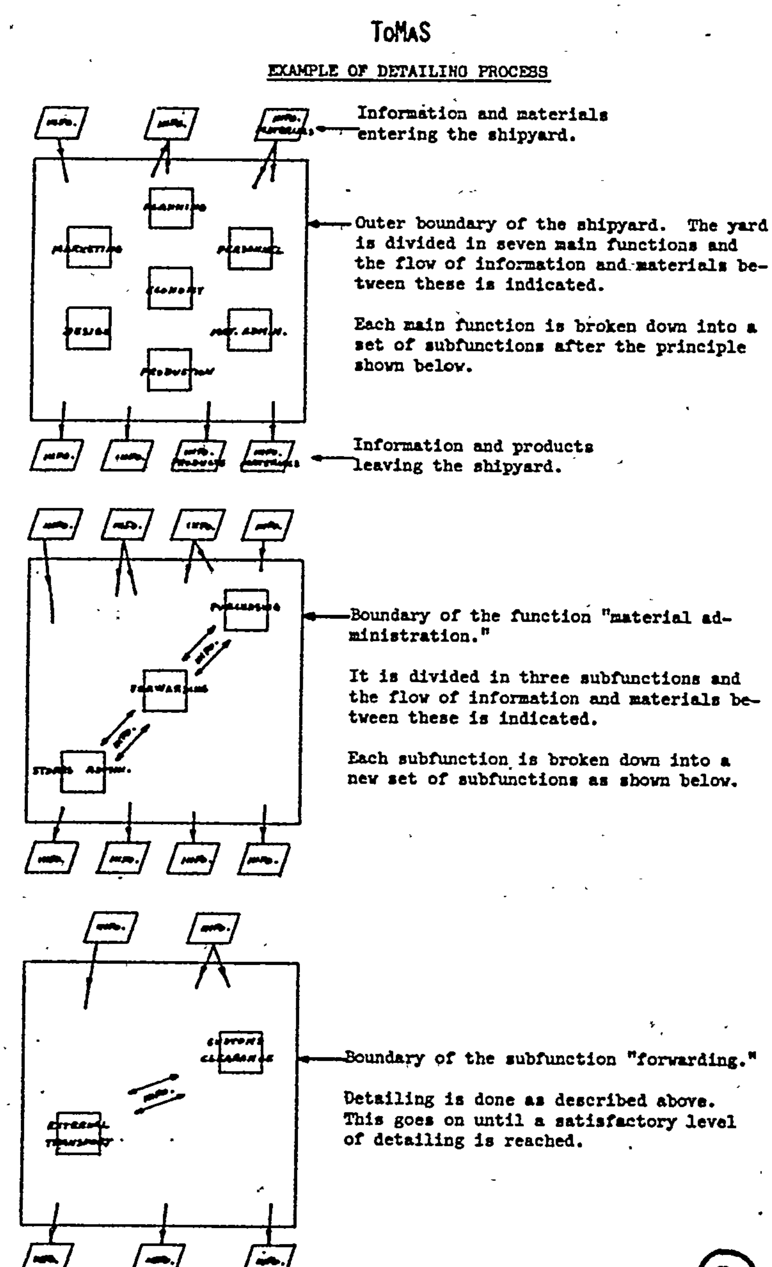
Phase 2:

On the basis of the material from Phasel, to suggest development projects for EDP solutions for suitable parts of the administrative information systems (in addition to existing EDP systems like MAPLIS, PLASIS, etc.).

To summarize, ToMaS is an integrated yet modular and flexible model of the shipyard's management functions and information systems. The information systems are hybrid: alternatives for manual execution, EDP or combination of these are possible.

Project Work Method

The analysis work in the ToMaS project is done according to the ISAC method (Information Systems for Administrative Control*). The main principle of this method is to start with a rough description of the enterprise (shipyard) and its interrelations with the environment, and break the enterprise down in functions and sub-functions. The analysis will, for each level of detailing, add new information about the field we are studying.



5.

* Developed in Sweden in cooperation by the Royal Technical University and the Stockholm University.

The Initial Project Work

The prestudy was concentrated on finding the logical main functions of the shipyard and giving a rough description of the interrelations (flow of information and goods) between the shipyard and,its environment and between the main functions.

The following seven main functions were decided upon:

PLANNING

MARKETING

PERSONNEL

FINANCE

ENGINEERING

MATERIAL ADMINISTRATION

PRODUCTION

ToMas is now composed of seven part projects, one for each main function.

3. MORE ABOUT ToMaS

As a conclusion for what said before, we can repeat that flexibility of operation can be enhanced if the functional divisions and complementary information systems have the same boundaries; the organization may change **but the basic functions. will remain and will have the same tasks and** corresponding information requirements.

What Do We Mean by Information?

We should be aware from the outset that when we use the terms "information" or "information flow" in the ToMaS context, that we are not merely referring to, for example, a document by name and title.

We should be aware of the total change in the nature of information which a document carries with, for example, the addition of an authorized signature.

We should be prepared to consider and answer the basic questions:

1. WHAT ? Information needed
2. WHERE ? Source, destination
3. WHO ? Sender, receiver
4. WHEN ? Date, frequency
5. HOW ? Transmission method

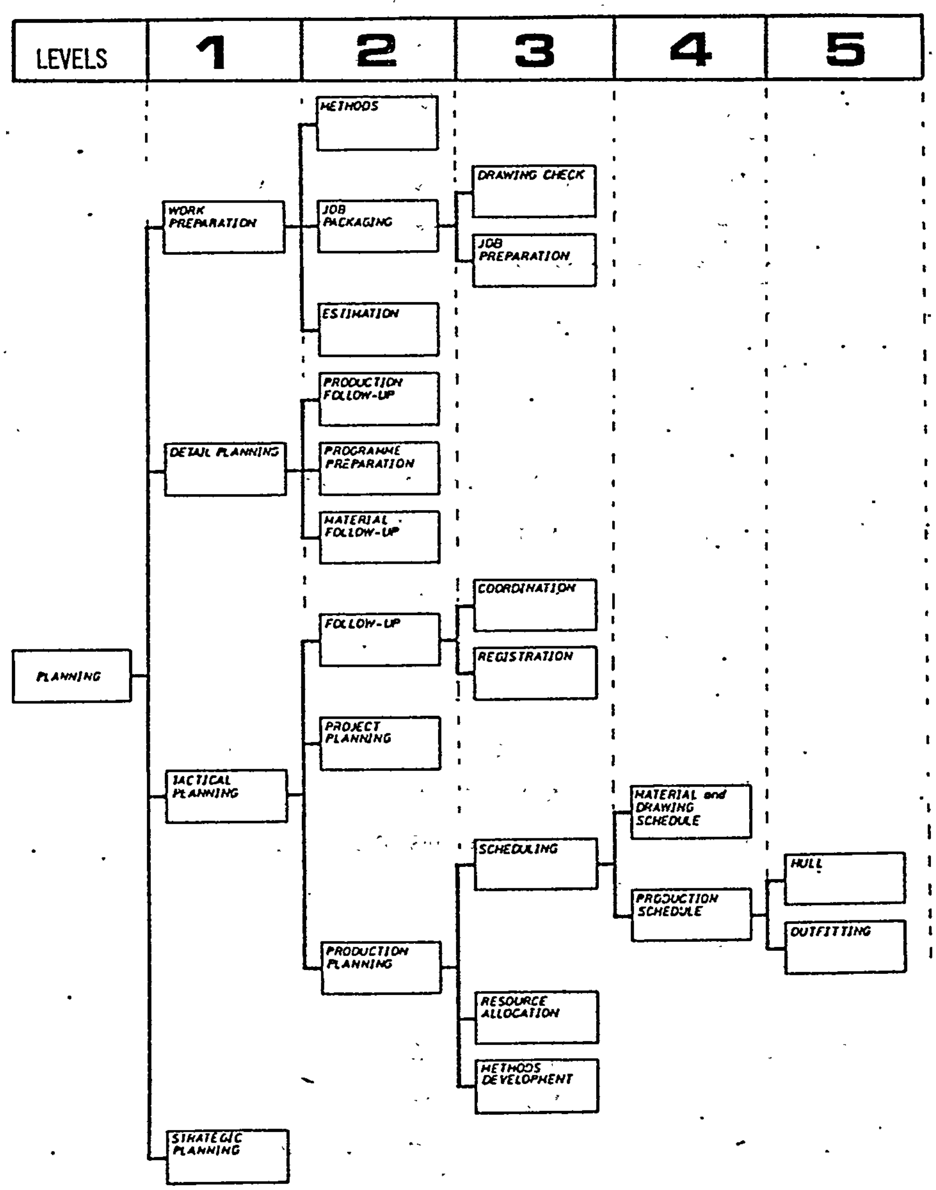
We should be aware that our information bearer carries information of both **an** identifying and informative character. **Lack of any one of these aspects** simply means that the model is incomplete and ambigous.

We will attempt to demonstrate the fidelity of the ToMaS model by providing some examples.

4. EXAMPLE 1

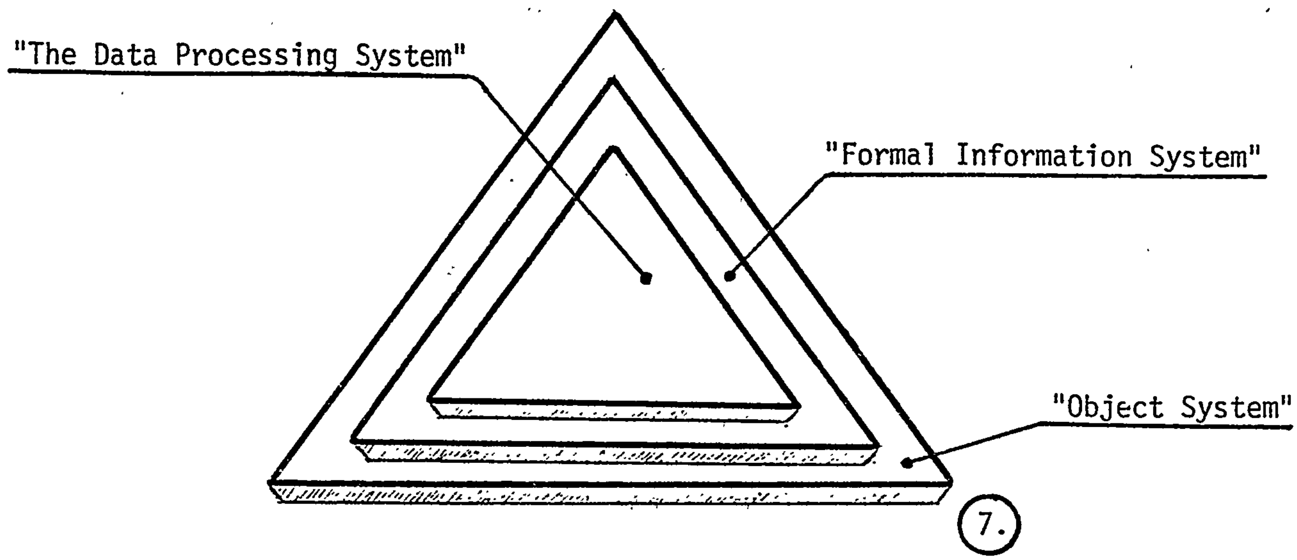
Functional Breakdown of the Planning Function

We notice that the ToMaS model provides, in this case, five levels of sub-division of the Planning Function. Each sub-function is further specified by a family of charts and matrices, the most important of which are presented as further examples.



6.

Two of the types of charts utilized in the model are referred to as "Object System" and "Formal Information System" charts respectively. To establish them in context to each other we use the simple diagram below:



"Object System"

An information system exists to serve a larger system, this larger system we refer to as an object system. Examples of object systems can be a shipyard, a function. A family of objects systems charts specifies an object system.

"Formal Information System"

The formal information which flows within an object system is only a part of the total information flow. Information also flows informally by, for example, direct contact between people. It is often neither economic nor desirable to formalize the informal flow of information.

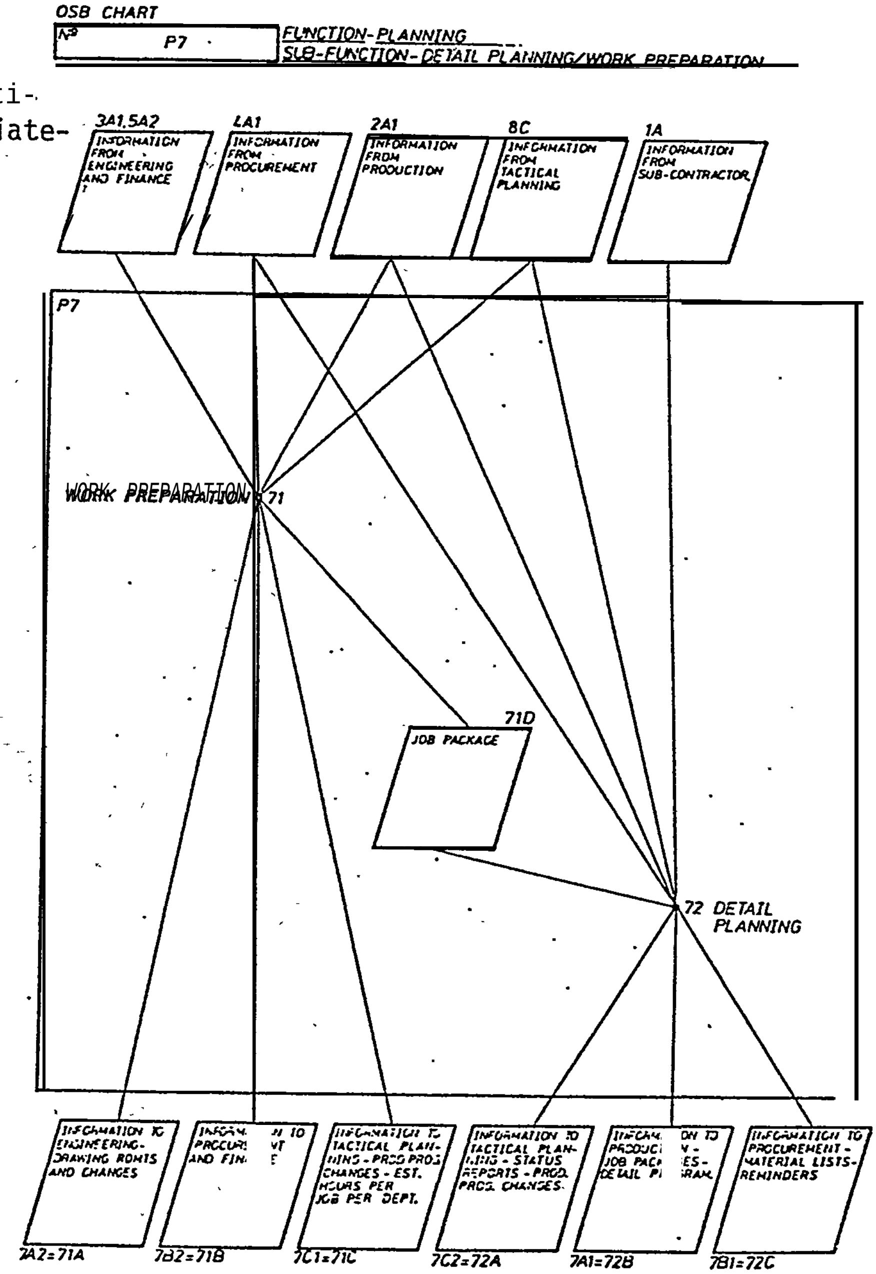
"The Data Processing System"

The data processing system, be it manual or computer aided, is simply an implementation of the abstract information system. Whilst the ToMaS model provides the system analyst with invaluable assistance, special data processing system have no place in the model itself, otherwise the organizational independence of the model is invalidated.

5. EXAMPLE 2

Detail Planning and Work Preparation.

In the example chart we notice that:



1. The chart bears the identification P 7 which immediately indicated that

   a. The chart belongs to the family PO

   b. Since there is one digit in the identification, it represents a sub-function in the first level or subdivision of the planning function.

   c. The chart is a detail of node 7 on chart PO.

. The large square and its contents represents the object system, "detail planning and work preparation."

. The parallelogram symbols represent units of information and those outside the large square represent the environment in which the object system operates.

4. Flow is invariably from top to bottom on the chart.

5. The nodes 71 and 72 will be further detailed on charts P71 and P72.

8.

6. The coding of the information units will also cross reference between charts in the same family. For example 2A1 on this chart will be found to be a part of 2A on chart PO.

Each chart is invariably accompanied by a more detailed specification of the information units and next level sub-functions.

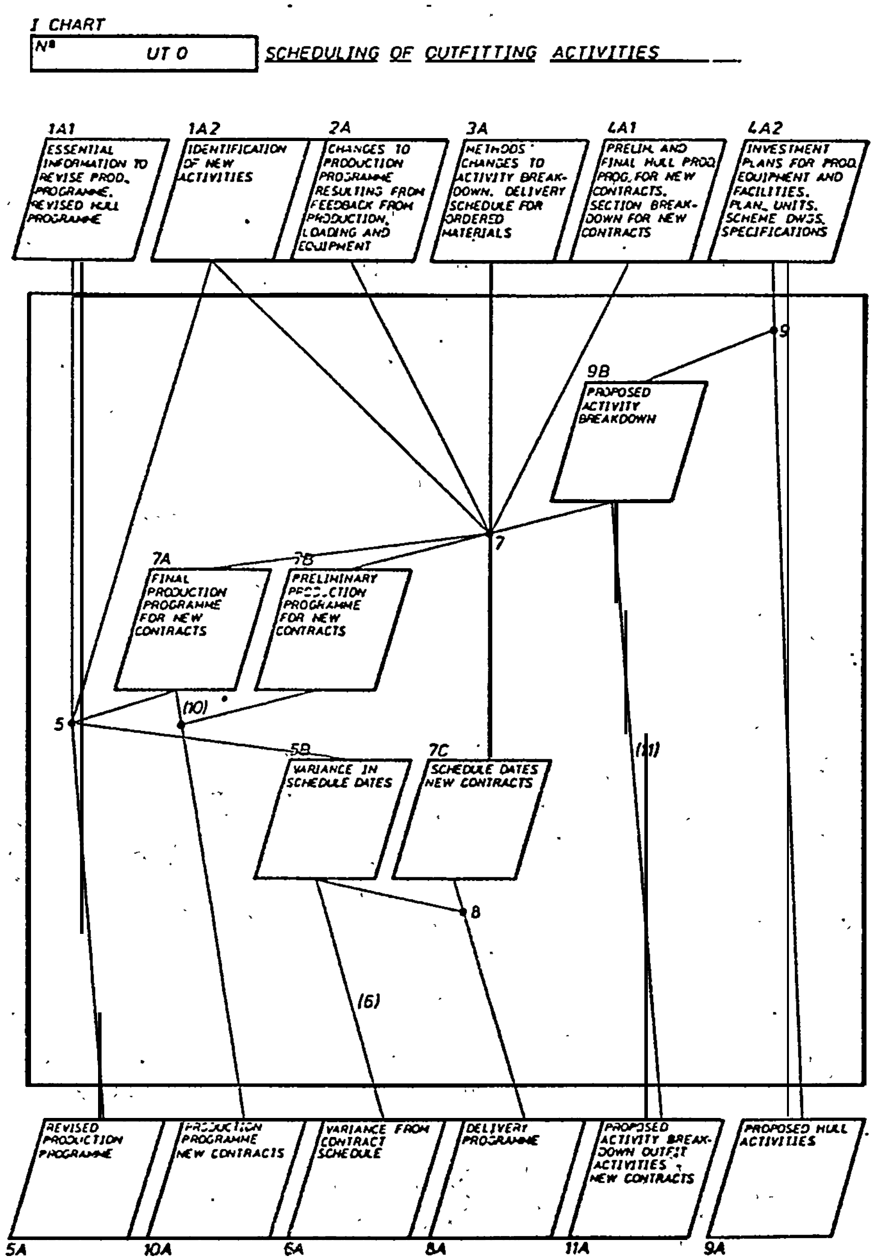
6. EXAMPLE 3

Scheduling of Outfitting Activities

The form of this example chart is very similar to the form of the object system chart, however, there are significant differences:

1. The nodes represent in this case some form for information processing.
2. The flow lines represent precedence - for example, to produce 5A, revised, production program, lA1, 1A2 and 7A must be available,- the routine to produce the revised production program being represented by node 5.

The information system charts are specified in detail in much the same way as the object system charts.

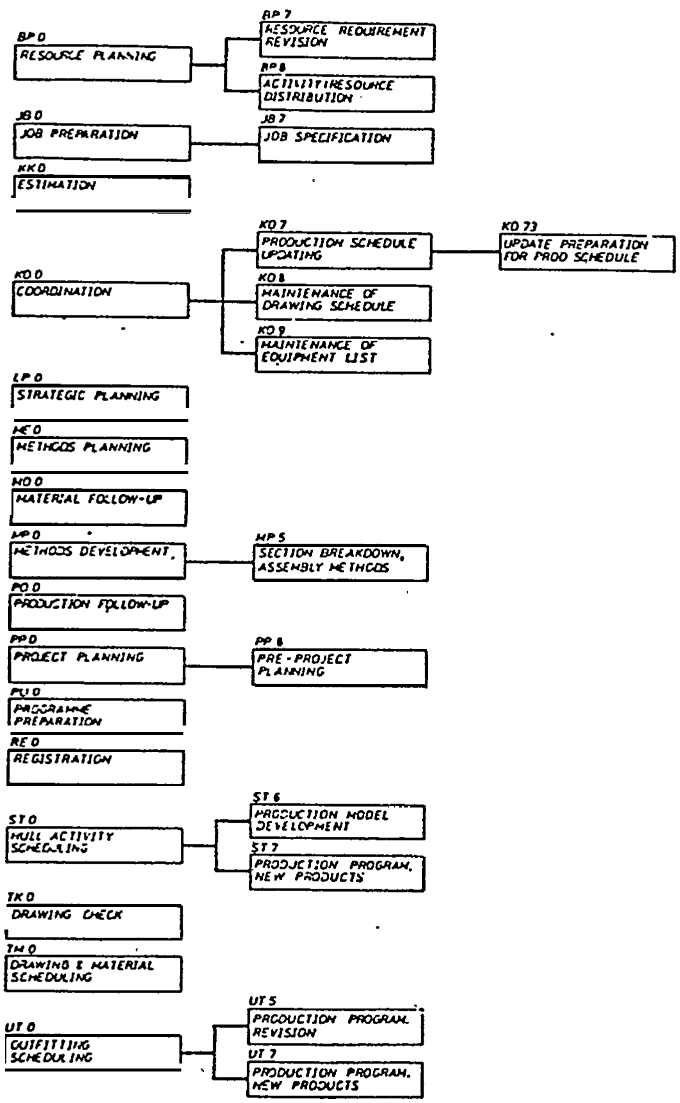


9:

7. EXAMPLE 4

Information System Charts - Planning Function

The extent of detail present in the ToMaS model can be appreciated by correlating this example with the first example and the seven ToMaS basic functions.



10.

8. STEPS IN THE ToMaS ANALYSIS

The SRS organization and management team are regularly engaged to study and recommend reorganization or indeed new organization-in shipyards. Normally this type of exercise will be conducted in three phases.

1. Pre-study phase, with the object to study and document the scope of the exercise based on agreed terms of reference.
2. Detail planning phase, recommend and agree the new organization structure with the client and prepare detailed plans for all aspects of its implementation.
3. Implementation phase, implement the new organization and establish all systems essential to its operation.

The ToMaS model has definite advantages to offer in all phases over and above the general advantages of quality, consistency and economy. In phase 1 the model provides the project team with a functional frame of reference to guide the study of the existing organization and its systems, ensuring

that all aspects are studied in the minimum elapsed time

a basis for comparison

common terminology

a documentation form which is designed to aid the type of analysis required at this stage.

In phase 2 the development of recommended organization structure in detail implies a detailed knowledge of the relationships between all functions and sub-functions at all levels such that they may be organized,to achieve the yards objectives. To man each organizational unit effectively requires not only knowledge of the units task but also knowledge of what it will receive and what it will provide. The management of the consulting project itself requires that the total effort can be broken into sub-projects without ambiguous interfaces. The object system charts together with their specifications provide an effective answer to these aspects of the overall task.

The characteristic of phase 3 is invariably the study and implementation of practices and procedures within organizational units as a number of individual projects with individual project teams. The danger here is the creation of ambiguity in the interfaces between the resulting procedures. The ToMaS object system models are unambiguously interfaced thus if applied diligently, this danger is reduced to insignificance. However, the object system charts are not sufficient in detail to ease the task of writing and implementing the individual routines themselves and the review and adaption of individual data processing systems.

The information system charts represent the bulk of the ToMaS documentation and take the form of chart families with detail descriptions.

NEW DEVELOPMENTS IN CNC AND DNC CONTROLLER EQUIPMENT FOR THE SHIPBUILDING INDUSTRY

Joseph W. Belanger
Kongsberg Systems Incorporated
Bedford, Massachusetts

Mr. Belanger is a System Consultant currently responsible for designs of CNC and DNC systems. He has 15 years experience as a designer of industrial equipment and systems and has been an owner of a systems design firm.

Mr. Belanger holds a degree in electrical engineering from Worcester Polytechnical Institute, Massachusetts.

New Developments in CNC and DNC Controller Equipment for the Shipbuilding Industry

I Introduction

My talk today is based upon a development activity that I have been involved with for the last 4 years at KSI.

The ultimate goal of this development program was to produce controller equipment that would function in a DNC network and allow the end user to begin to achieve an "INTEGRATED MANUFACTURING APPROACH" to the flame cutting process.

Before I continue any further, I feel I must define some terms in order for all of us to have a common understanding of the concepts that will be introduced.

Currently, those of you who are involved with flame cutting in your yard are probably operating with either optical template or NC (Numeric Control) flame cutting equipment, In the case of the NC equipment, the controllers for this equipment are either NC "hard wired" units or CNC (Computer Numeric Control) "soft wired" units. The difference between “hard wired” and “soft wired” being the CNC controller has a general purpose digital computer as its central component, and thus, is programmed by “software” within it as opposed to being a series of fixed functions in “hard wired” controller.

Chances are, these NC or CNC controllers function entirely from paper tape. - The paper tape represents a single part or a “nested” series of parts arranged so that an entire plate can be utilized during-a single burning machine set-up.

The actual parts represented in the paper tape were probably-generated via some CAD (Computer Aided Design) function either operating in your own yard or some remote CAD service center accessed by a computer terminal connected to the telephone system.

It should be noted at this point that generally speaking, all of these functions operate independently of each other. Coordination is left to the individuals involved. The actual part program data is committed to a physical paper tape that must be-manually coordinated, again by the individuals involved. On the other end of the cutting process, that is the actual cutting operation, all operating information about that particular cutting process must be derived by manual reports, again, written by the individuals involved.

The development effort at KSI set out to integrate as many of these individual functions into a common computer based DNC (Direct Numeric Control) network. The ultimate goal of the DNC network is to provide paths for an automatic flow of information between CAD (Computer Aided Design) functions, DNC (Direct Numeric Control), and CAM (Computer Aided Manufacturing) functions. Once the DNC network is installed and becomes operational, the end user can

then begin to approach “INTEGRATED MANUFACTURING” on a practical basis.

II Network Component Design Criteria

On terms of designing controller equipment and computer systems to make up this kind of a DNC network, it was felt that all of the designs should meet the following general criteria:

(1) The network should be able to incorporate as many nodes or work stations as possible. The more individual work stations tied to the network, the higher the level of INTEGRATED MANUFACTURING achieved.

(2) The end user should not be forced to replace his existing equipment prematurely in order to achieve the DNC network. The practical feeling being that very few companies can or would commit to wholesale replacement of their existing controllers and/or burning machines and thus limit DNC network to very slow growth.

(3) All network components should be built around existing mass produced domestic mini-computers in order to achieve the highest level of integrated circuit “state of the art” at the lowest cost, provide a completely modular system expansion capability, and reduce maintenance to a minimum of complexity.

III The Network Components

(1) Burning, Machine Controller Component

The first network component designed and built was a new CNC controller. This controller was built around the Digital

Equipment Corporation PDP 8-A mini-computer. It contains all of the necessary generally accepted standard burning machine control features found on any modern CNC controller. From an operators point of view it concentrated the entire control function-to a single operators panel generally mounted on the beam of the burning machine. The actual computer in the controller is generally located up to 3000 feet away from the burning machine and is connected to the burning machine via two small cables. This concept has proven itself in actual installations involving both oxy-fuel and plasma burning, and as a general purpose 2-1/2 axis controller it is equivalent to any modern stand-alone conventional controller employing paper tape as an input medium.

This, however, is where the similarity ends. The controller is actually a network “node” as well as a controller. It has the ability to communicate in both directions with a remote DNC computer while it is also directing the burning process. An operator can, via the control panel, call for a specific . part located in some centralized parts library attached to the DNC computer. This same DNC computer can direct the operator to burn specific parts in accordance with some master schedule. When the actual burning machine begins the burning of the part, the controller monitors the various functions such as torch relay on, speed setting, etc., and automatically transmits them to the DNC computer. The DNC computer in turn, logs the event and stores it for later processing. The controller thus

becomes an input/output device to a DNC network receiving and transrmitting control information. This capability is one of the basic steps necessary in achieving INTEGRATED MANUFACTURING.

In order to satisfy the design criteria of not forcing the end user to replace his existing equipment prematurely in order to achieve the DNC network, the controller has been designed in several forms.

(1) NEW CONTROLLER, NEW BURNING MACHINE; in this case the controller is a straight forward addition to the burning machine and generally is installed by the manufacturer of the burning machine. (2) NEW CONTROLLER, OLD NC BURNING MACHINE; in this instance the controller is retrofitted to an existing NC burning machine and the original NC controller is replaced. (3) NEW CONTROLLER, OPTICAL TRACER BURNING MACHINE; currently work is being performed on a retrofit package that will allow an Optical Tracing burning machine to be upgraded to an NC machine. The end user will have the option to switch back and forth between Optical and NC as desired. When the system is switched to NC it becomes a DNC network node with all of the capabilities of the standard NC controller. (4) NEW CNC BURNING MACHINE; in order to accommodate end users-who have invested in NC burning machines and do not wish to replace the controller, but do wish to attach the machine to the DNC network, an additional network

component was developed. This component is connected to the existing controller at the paper tape reader connection and functions in a “Behind the Reader” (BTR) mode. The BTR component provides all of the network communication capability thus making the attached CNC controller a functionally equivalent network node.

With these four combinations it is possible to completely incorporate any combination of burning machines in a shipyard into a DNC network without extensive across the board capital equipment replacement.

(2) DNC Central Computer Component

Having discussed the Burning Machine Controller components, which represent the ends or nodes of the network, I would now like to discuss the development of the central element of the network. Information coming from any external source destined for any other external node must be controlled by, and passed through, this control element. A major design criteria for this central element is that it be flexible enough to accommodate a wide range of diverse uses and be capable of meeting the requirements of both large and small networks.

Another major design criteria was the need to be able to not only, communicate internally with the end nodes of the DNC network, but to also have the capability of communication

to the outside world. This would allow for the connection of the network to any outside CAD service such as Spades or Autocon.

The resultant development effort produced a centralized DNC computer system built” around the general purpose Digital PDP-11 Computer family. The internal operation of the system is divided into three general categories, DNC operation, CAD operation, and CAM operation. These three categories are all under the control of a master executive operating system and each category is capable of operating independently within the computer at the same time.

The major functions of the DNC operation involve actual communication with the burning machine controllers. A central parts library is accessed by the DNC subsystem and the requested part is fetched from the library and transmitted to the requesting node in the network. The DNC subsystem is also responsible for collecting operational data coming in from the burning machine nodes, time stamping each piece, and storing the results for later use.

The CAD operation concerns itself with allowing the user to perform part edit and verify functions, or to communicate directly to an external CAD service via telephone lines. In either case the program parts being worked upon are then directly stored into the central parts library.

The CAM operation concerns itself with Management Information

Systems (MIS) work. Programs operating within this category can have access to data stored within the centralized storage system and produce customized management reports.

All of these subsystems, DNC, CAD, CAM, have been designed to be open-ended. This means that they can readily accommodate additional features or applications as they become available.

IV Applying the Network to INTEGRATED MANUFACTURING

Once the network is installed, the end user can then begin to integrate his manufacturing process. The reason I say the word begin is because I believe the process is an evolutionary one.

The immediate benefits the user will experience are:

(1) Complete elimination of physical paper tape

(2) Establishment of a common Parts Library that is easily accessible by both individuals programming the parts, and by individuals burning the parts

(3) Automatic burning machine operations reports derived from the information gathered from actual operation

The network is capable of going much further than that, however. The open-ended design of the DNC, CAD, and CAM subsystems within the central DNC computer allow for additional features to be added in the future. Thus each individual network can grow as much as the user desires. For example, the CAM subsystem could incorporate an Inventory Control Application Program, either based upon an external inventory control system, or one operating entirely within the network. This inventory

control program could interface with the actual burning information derived from the DNC subsystem. Another application program could be to set up a burning schedule that would automatically inform the burning machine operators which plate is next, etc. This application could also interface with the inventory control application. The CAD subsystem could accommodate a nesting application, and so on--.

The main point is that once the-network is established, the tools are there to use. I believe each individual installation with a network of this kind will evolve differently, each customizing to meet their individual needs.

The limit of the network’s usefulness is a function of the users desires, motivations, and commitment of energy to make the network perform.

DNC/CNC PLATE CUTTING AT BATH IRON WORKS

George H. Peck
Bath Iron Works Corporation
Bath, Maine

Mr. Peck is a Systems Analyst responsible for computer applications and engineering and production. He has a B.S. degree in engineering from C.G. Academy and a M.S. degree in business administration from the University of Connecticut.

Russel M. Morgan
Linde Division, Union Carbide Corporation
Indianapolis, Indiana

Mr. Morgan is Manager of Engineering for the cutting machine manufacturing department. He has 10years experience in designing numerically controlled flame and plasma arc cutting machines. Mr. Morgan has a B.S. degree in electrical engineering from Rutgers University, New Jersey.

As the result of a prior commitment with the U.S. Coast Guard Reserves, Mr. Peck will not participate in the presentation of the subject paper this morning. Mr. S. C. Endris, N/C Project Superintendent at the Bath Iron Works Corporation, will deliver Mr. Peck's portion of the paper.

INTRODUCTION:

Bath Iron Works (BIW) is located in Bath, Maine, a community of several thousand people situated approximately 40 miles north of Portland, Maine.

(Slide #l & #2)

The principal business of BIW, presently and as in the past since the late 1800's, is Shipbuilding. The present workforce totals about 4,000 people. BIW, in recent months, built and delivered the OLIVER HAZARD PERRY (FFG-7), Lead Ship in the Navy's latest generation of Guided Missile Frigates.

(Slide #3)

Also, on May 24, 1978, BIW delivered the 720 foot Containership, MAUI, to Matson Navigation Company of San Francisco.

(Slide #4 & #5)

The present shipbuilding backlog at BIW includes the construction of eleven (11) guided missile frigates of the PERRY Class for the United States Navy and two (2) SEA WITCH Class Containerships for Farrell Lines.

Additionally, BIW-is actively involved in the ship repair and overhaul business and industrial fabrication work.

In order to present a complete overview of DNC/CNC cutting at BIW, the paper will concentrate on the following topics:

(VIEWGRAPH #1)

- ABSTRACT - Required System Capabilities (BIW)
- System Configuration (UCC)
- Job File Structure/Design (UCC)
- Actual Operation (BIW)
- **General Results** (BIW)

ABSTRACT - Required System Capabilities

The procurement and implementation of any major new system or process within the production environment, and I include design and engineering in this context, can potentially create much apprehension and confusion resulting in schedule disruptions. If. this is allowed to happen, acceptance of the new process by the users (employees) may be delayed. Accordingly, the full benefit of the system's or processes' capability may not be immediately realized thus reducing a company's initial return on investment.

Therefore, it was--the opinion of BIW that in order to ensure a smooth and effective system implementation BIW must define,in detail, the technical and scheduling requirements expected from the proposed DNC System.

(Viewgraph #2)

- Technically Define System's Requirements

and

- Establish Equipment Delivery, Installation and Activation Schedules

This developed into a tough assignment considering that BIW personnel had not acquired much knowledge of N/C systems and equipment at this time. Realizing the aforementioned, BIW elected to participate in the IITRI Managed AUTOKON Support Program.

Reviews of IITRI produced papers assisted in the technical definition of BIW'S desired DNC/CNC System. Viewgraph #3 represents BIW's overall DNC System requirements as presented to the prime contractor - Union Carbide and as in operation at BIW today.

(VIEWGRAPH #3)

Technical Requirements of BIW'S DNC/CNC System

- DNC - This stands for Direct "Numerical Control. BIW'S DNC System is one in which a central mini-computer provides data to a number of cutting machines and a plotter At each machine there is an item called a machine control unit (MCU) which accepts the data from the central mini-computer and translates it into machine commands. In Bath's system, the central computer provides the data in the same format as paper tape. In essence, the central computer is replacing the tape reader. The advantages are elimination of tape problems, mass storage of programs and increased control and speed.

- AUTOKON is the software system in use at BIW. The N/C equipment is compatible in all aspects with the AUTOKON System.

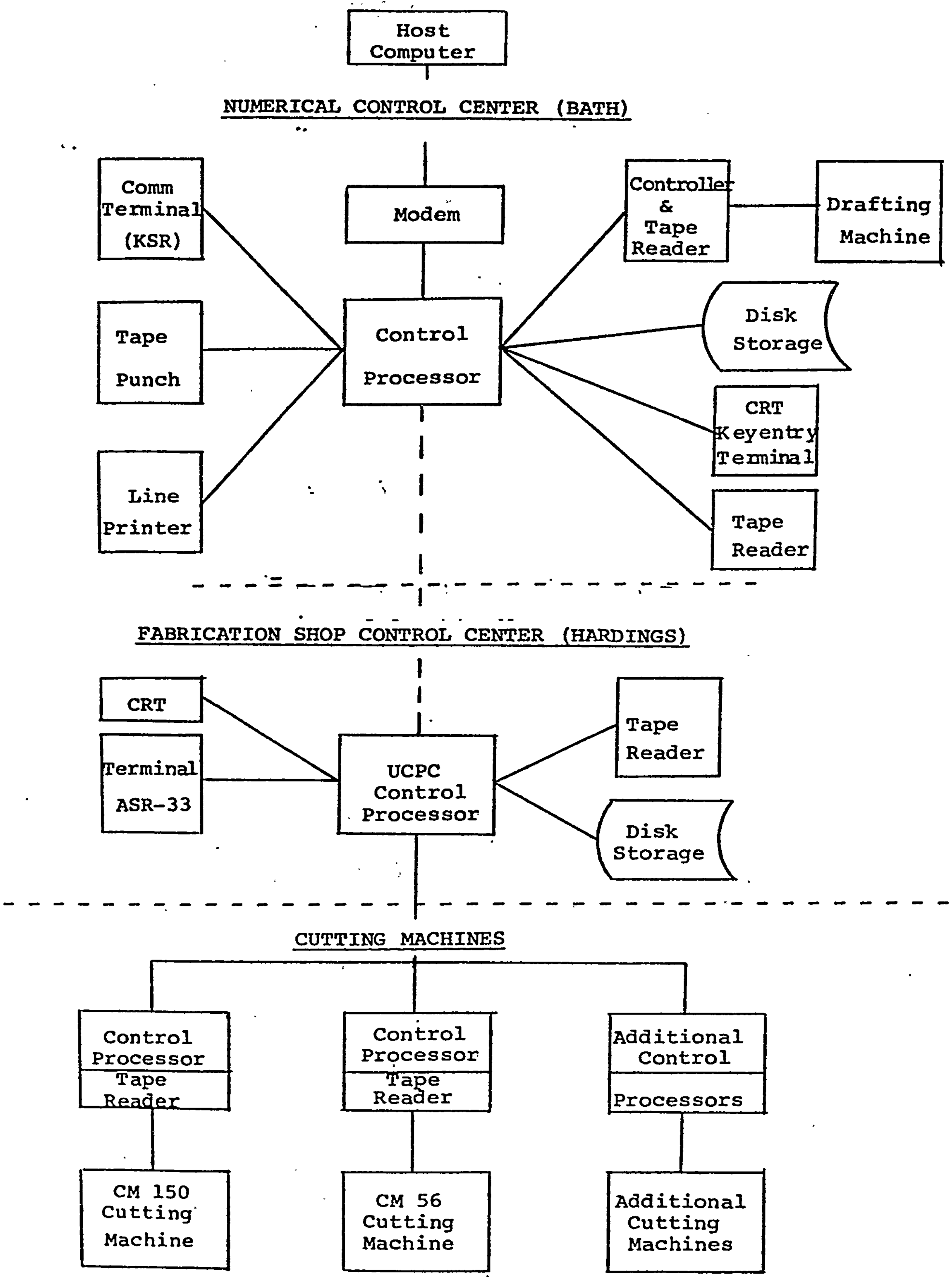
- The Host Computer is an UNIVAC 1108.
- A Remote Job Entry communications terminal is used to connect the N/C equipment center with the host computer.
- Key Entry and Verification by means of a disk storage medium is standard practice at BIW for other systems. Accordingly, a floppy disk system is used to facilitate standardization.
- Paper Tape is used as a back-up system only.
- Centralized Control of the Cutting Machines is essential at BIW in order to achieve the required material thruput. Accordingly, personnel in the Fabrication Control Center direct the raw-material flow to the desired cutting machine and, by utilizing DNC, forward the appropriate cutting data to the correct, machine.
- Multiple Task Operations of the communication terminals is utilized to support all of the possible operations of the equipment within a realistid time frame.
- Equipment Reliability is essential to tight production schedules.

As nreviously stated, the information and system requirements contained in Viewgraph #3 formed a major portion of the purchase agreement with Union Carbide and basically established the overall system configuration. Using this information, R. M. Morgan, Manager of Engineering at Union Carbides Advanced Systems Division, developed the hardware and software configuration to accomplish Bath's requirements.

SYSTEM CONFIGURATION (Viewgraph 4 & 4a)

The Distributed Numerical Control (DNC), Computer Numerical Control (CNC) System at the Bath-Harding facilities was designed as a Remote Job Entry (RJE) terminal, real time Disk Operating System (DOS), Plotter Verification Center and direct control of the cutting machine numerical controls (DNC) in a completely tapeless and cardless operation. The real time operating system has been designed to allocate the various resources of the computer system in response to request from the connected peripheral hardware in a large, batch-oriented N/C system such as Autokon or Spades. The heart of this is the terminal computer and the Disk Operating System (DOS) for controlling the CRT, line printer, storage devices, modems and the communicated terminal used by the operator. The operating system (DOS) has been written to emulate a card reader system but without the need for readers and punches (backup mode). The operator loads the disk via his terminal-device and the disk information is sent directly to the Univac computer when the two computers are connected. (called send file). Nhen the Univac computer completes its calculations the programs are sent to the Bath terminal (called receive file) in the form of a print and punch files. The print file information is directly printed on the Data 100 high speed line printer, the punch files are stored on the disk designated for receiving.

BIW'S DNC/CNC SYSTEM CONFIGURATION VIEWGRAPH #4



These output punch files that are stored on the receive disk are then checked on the plotter and when correct and-ready for cutting, -organized and stored on two diskettes - one as a master and the other for sending to the burning machines.

The second diskette is logged out by the Production Control Department, attached to the instruction sheets, plots. etc., and as a package, sent to the Harding Control Center. The Fabrication Control Center operator (controlling the cutting machines and plate handling system) loads the disk electronically to the burning machine when requested by the machine operator. The reason for this Direct Numerical Control (DNC) System is to automate the distributing and controlling of machine programs generated at the Bath Terminal. This system completely eliminates the major,weakness of a numerical control - paper tapes, tapepunches, tape readers and the wasted time to control and generate. When all programs on a particular disk has been cut, the disk is returned to Production Control, logged back in and stored with the master. This return procedure reduces the chances of later accidential cutting and for future use.

The Harding System has the capacity to communicate directly with four cutting machines and if needed, direct batch communication with the Bath Terminal. At present this final loop will not be closed, as Bath with the present system, has better control of where things are, what is cut and what programs are returned. With the present system all information is received as a complete packet when needed from Production Control. A daily messenger now carries daily mail, drawings, etc. so why not include the diskette with the drawings. For this reason, the cost of modems, Bell Lines and computer input-output (I/0) is not justified. The present method of operation also reduces the possibility of conmmunications error over the Bath Harding Network.

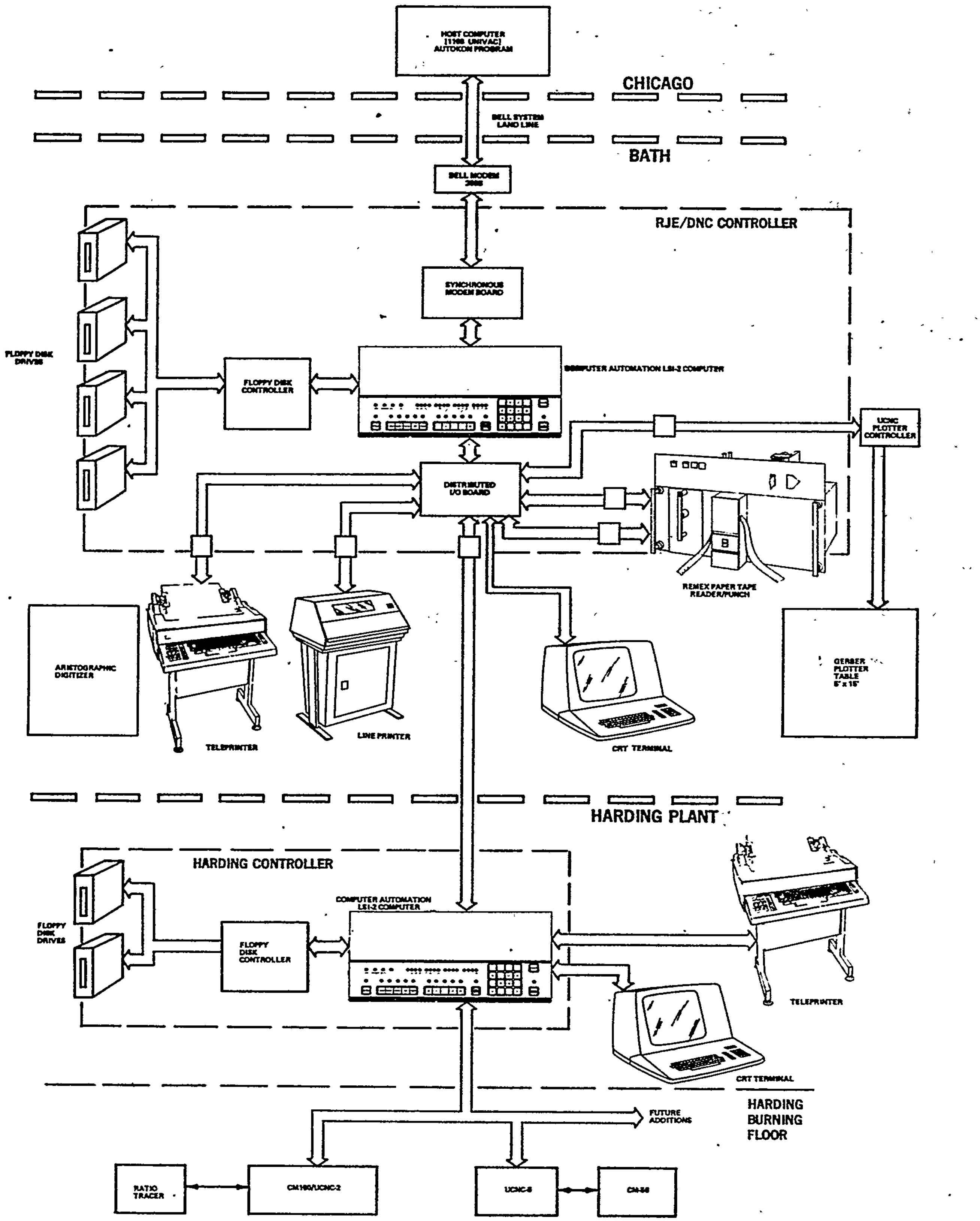
HARDWARE

Viewgraph 4A depicts the configuration for the Bath Terminal System and the Harding Burning Facility. The system processors are standard 16 bit mini-computer systems using 32K of memory. A total of 8 I/0 slots are provided for peripherial units, and a Direct Memory Access (DMA) channel interface for high speed block data transfers to the disk drives.

The synchronous communication controller/interface provides the data Link via a standard Bell (like 208B) modem to phone lines for accessing the central Univac 1108 Host computer. It is RS-232 compatible and can accommodate synchronous data transmission at rates of up to 4800 Baud.

The system console may be either the standard 24X80 CRT Keyboard display or the Centronics 701 teleprinter, depending on which is selected by the operator. Its primary function is in entering and receiving system-related information (commands, data, local programming, etc.) and as the operator console for RJE jobs for those RJE protocols which require the presence of such a device.

The 132 column Data 100 impact type line printer rated at 300 Lines Per Minute (LPM) is compatible with the nomjnal data rate of 4800 Baud. That is, at this data rate the device neither forces the central site computer to wait for them long periods of time nor forces the terminals' system processor to wait for the communications line to finish handling data for them. Functionally, the 75 character/second Paper Tape Punch is used to punch out the verified N/C tapes, when required, to run the numerically controlled flame cutter. Prior to transmitting this tape to the burning ship, the tape will typically be read back into the punch file (stored on the disk) from which it was produced to verify its accuracy. The PTR & PTP are used as a backup system at Bath.


HOST COMPUTER
AUTOKON PROGRAM
CHICAGO
BELL SYSTEM LAND LINE
BATH
RJE/DNC CONTROLLER
SYNCHRONOUS MODEM BOARD
COMPUTER AUTOMATION LSI-2 COMPUTER
FLOPPY DISK DRIVES
FLOPPY DISK CONTROLLER
DISTRIBUTED I/O BOARD
REMEX PAPER TAPE READER/PUNCH
TELEPRINTER
LINE PRINTER
CRT TERMINAL
HARDING PLANT
HARDING CONTROLLER
COMPUTER AUTOMATION LSI-2 COMPUTER
FLOPPY DISK DRIVES
FLOPPY DISK CONTROLLER
TELEPRINTER
CRT TERMINAL
FUTURE ADDITIONS
HARDING BURNING FLOOR
RATIO TRACER

The Shugart disk drives serves two essential purposes in the terminal system. First, since a real time multi tasking operating system is being used, the drive serves--as an extension to the terminal memory for task,swapping; Secondly, it serves as a repository for both system and user programs and data. Four removable disk units, as shown in Figure 4a can store-approximately 1,000,000 characters of punch file information (approx. 8,000 feet of tape).

JOB FILE STRUCTURE/DESIGN

Floppy Disk System

(Refer to Viewgraph #5).

The floppy disk system has proven to be very easy to work with and inexpensive storage. 'Both fixed disk and floppy disk were studied in the original design. The floppy disk being chosen for its price and flexibility. The terminal system contains four disk drives which are normally assigned as follows.

Drive Ø - JCL Diskette

Drive 1 - Manuscripts

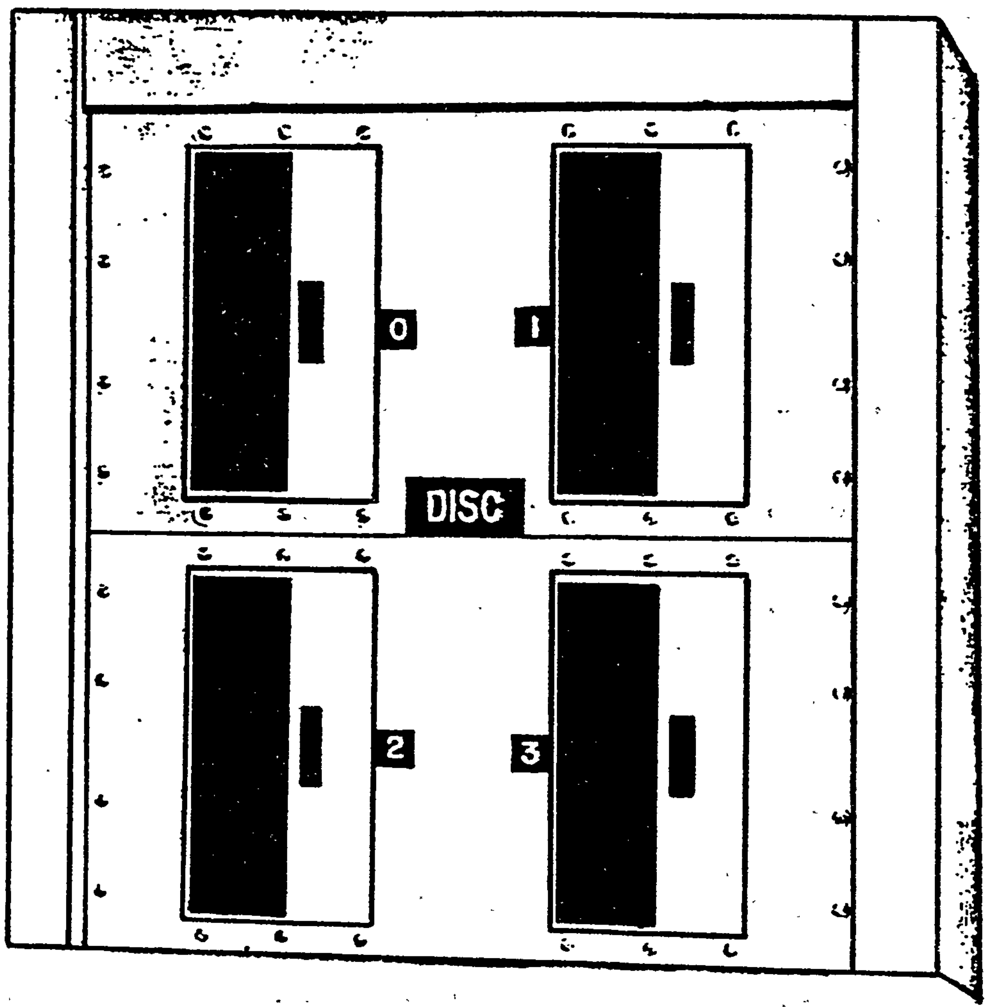
Drive 2 - Autokon output (receive file).

Drive 3 - Plotter Data

FLOPPY DISK SYSTEM

JCL

Manuscripts



Output

Plotter Data

The system has been designed to allow multiple operations at the same time. This allows key entry and plotting to occur concurrently. Segregating data on specific drives and stating the disk drive in the read write or plot command provides a very efficient operating-system with little interruption to slow down either operation

BIW'S cutting machine is located in the Fabrication Shop (Hardings) approximately four miles from the shipyard and the loft area (Bath) where the Numerical Control Center is located. The modular construction methods employed at Bath Iron Works adapt very well to the floppy disk concept. A diskette is prepared with the cutting data for one construction unit. A copy of the diskette is prepared with one going to the cutting machine area and the other being retained in the Numerical Control Center. This enables the cutting machine area, to operate independent of the Numerical Control Center.

FIoppy Disk File Structure

(Refer to Viewgraph #6)

The floppy disk file structure consists of files and a further breakdown of subfiles within files. This structure has worked very well in relation to modular construction. Many parts comprising a unit can be associated with the construction unit very easily. Due to the way the directory is set up, a maximum of 47 files may be placed on one diskette. Utilizing the subfile structure which has no limitation, maximum utilization of each diskette can be accomplished. The only restriction to the size of file/subfile structure is the size of the buffer used for file reading and writing. In order to modify a file, the entire file must be read into the computer memory buffer which has a limitation of about 14,000 characters. Therefore, by keeping track of the number of characters in a file as shown by taking a catalog of a file, maximum diskette space is utilized as shown by the directory of disk drive 2 where 147 out of a possible 219 sectors are occupied.

FLOPPY DISK FILE STRUCTURE

I. FILENAME
   II. SUBFILENAME

- Directory gives a listing of all files
- Directory gives the number of sectors occupied by a file
- Catalog gives a listing of all subfiles within a specific file
- Catalog gives the number of characters within each subfile

DIR 2

DIRECTORY DRIVE F2					DISK 1013	
NEFB11	0	0	0	0	1978/5/12	12
NEFB12	0	0	0	0	1978/3/8	12
NEFB13	0	0	0	0	1978/3/9	10
NEFB14	0	0	0	0	1978/3/22	11
NEFB15	0	0	0	0	1978/4/19	2
NEFB16	0	0	0	0	1978/5/3	9
NEFB17	0	0	0	0	1978/5/4	10
NEFB18	0	0	0	0	1978/5/22	3
NEFB19	0	0	0	0	1978/5/19	10
NEFB20	0	0	0	0	1978/5/19	8
NEFB21	0	0	0	0	1978/5/30	11
NEFB22	0	0	0	0	1978/5/31	9
NEFB23	0	0	0	0	1978/5/31	9
NEFB24	0	0	0	0	1978/6/1	9
NEFB25	0	0	0	0	1978/6/1	9
NEFB26	0	0	0	0	1978/6/1	10
NEFB27	0	0	0	0	1978/6/2	3

Number sectors occupied by file

17 ENTRIES. SPACE USED 147 OF 219

0:CAT 2,NEFB15

NEFB15

	76
#NC-1154-05#	161
#NC-914#	404
#NC-195#	647
#NC-335#	166

Number characters per subfile

File Name Structure

File names for manuscripts, send files, receive files, and job control language have been designed for easy access and traceability of documents.

(Refer to Viewgraph #7)

Manuscripts or Autokon programs begin with a two character data-base designation followed by a four character structural unit designation. Then there is a seven digit piece number followed by a two digit programmer identification number. The piece number and programmer identification number appear on the programmers' original handwritten manuscript, it appears on the computer generated output manuscript and is automatically generated by the Autokon System as a label for the plotted part. This enables the Numerical Control Center to keep all the documents for a given part in one package.

(Refer to viewgraph #7A)

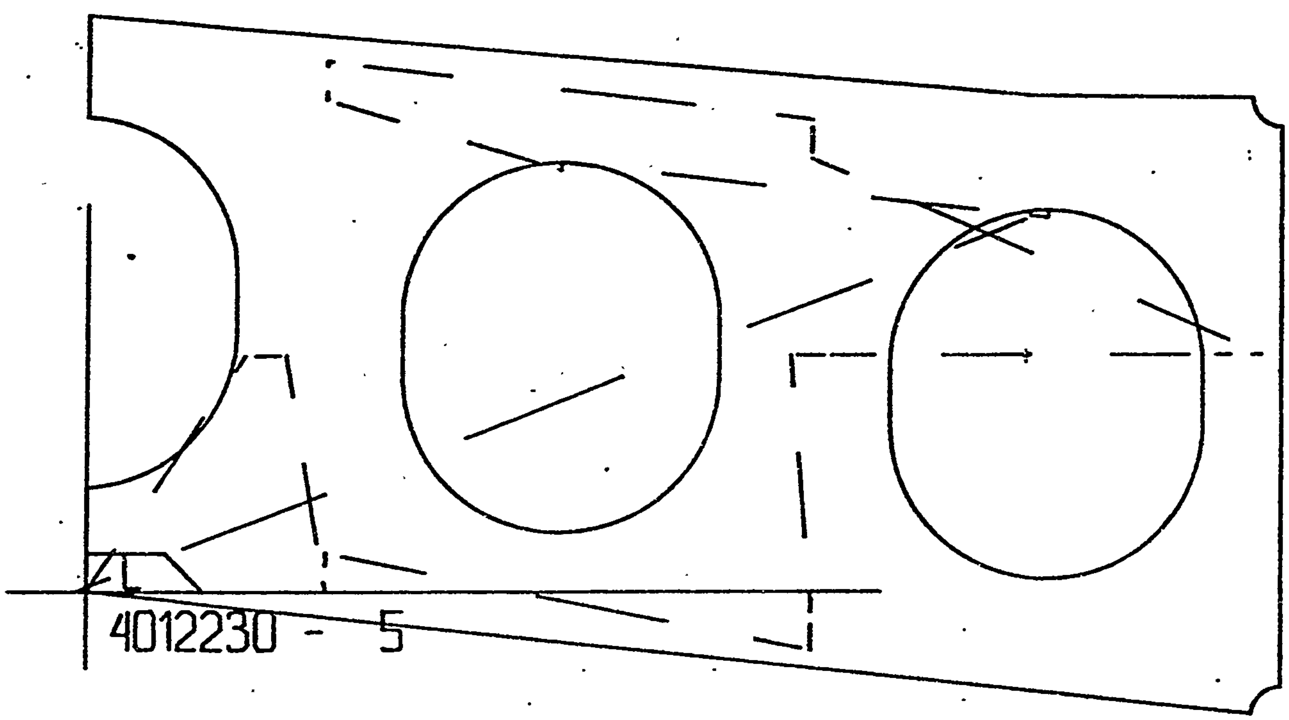
VIEWGRAPH #7

MANUSRCIPT (PROGRAM) NAME STRUCTURE

XX	XXXX	XXXXXXX	XX
DATABASE DESIGNATION	SHIP STRUCTURAL UNIT DESIGNATION	PIECE NUMBER	PROGRAMMER IDENTIFICATION

EXAMPLE: $\underbrace{\text{FBØ2Ø1}}_{\text{FILE}}\ \underbrace{\text{2Ø172Ø1 Ø6}}_{\text{SUBFILE}}$

Viewgraph #7A



(Refer to Viewgraph #8)

Send files are created which tell the system what information should be sent to the Autokon System for execution. The file names consist of a two character send file designator; a four digit date, a daily sequential number, and a two character Autokon designation. The send file designator is SF or SA signifying a send file for the forebody database or aftbody database.

(Refer to viewgraph #9)

Receive files are named in a similar fashion to send files and enable the output data to be associated with the data sent. A two character receive file designation, RF for receive forebody database and RA for receive aftbody database. A four digit date, a daily sequential number and an Autokon module designation.

VIEWGRAPH #8

SEND FILE (JOB STREAM) NAME STRUCTURE

XX	XXXX	X	XX
SEND FILE DESIGNATION	DATE (MMDD)	DAILY SEQUENTIAL NUMBER	AUTOKON MODULE DESIGNATION

VIEWGRAPH #9

RECEIVE FILE (AUTOKON OUTPUT) NAME STRUCTURE

XX	XXXX	X	XX
RECEIVE FILE DESIGNATION	DATE (MMDD)	DAILY SEQUENTIAL NUMBER	AUTOKON MODULE DESIGNATION

EXAMPLE: $\underbrace{\text{RF}}_{\text{Receive Forebody}}$ Ø627 1$\underbrace{\text{AL}}_{\text{ALKON}}$

JCL File Structure

(Refer to Viewgraph #lO)

Job control language consists of the instructions necessary to execute the Autokon System on a Univac 1108 computer. Job control language has been prepared and keyentered for all Autokon modules currently in use by Bath Iron Works. Because the control language is stored on a floppy disk, file names had to be generated in-order to retrieve the control statements as needed. Names were generated which would enable the Numerical Control Center operators to select the proper control statements with minimal information from the programmers. The names consist of a three character designation for job control language, a one character heading or ending designation, a two character database designation, a two character Autokon module designation and a one character priority designator. It can be seen that by knowing which database to access and which Autokon module is to be utilized, the correct job control language can be selected.

<u>JOB CONTROL LANGUAGE (JCL)</u>

XXX	X	XX	XX	X
CONTROL LANGUAGE DESIGNATOR	HEADING ENDING DESIGNATOR	DATABASE DESIGNATION	AUTOKON MODULE DESIGNATION	PRIORITY

Aft Body

EXAMPLE: JCL H AB AL Z

ALKON

Heading

RJE Structure

(Refer to Viewgraph #11)

The Remote Job Entry or RJE command directs and will seek and send the file or files to the host computer for processing. It also directs which file is to be used as a data receive file.

(Refer to viewgraph #12)

In the following example, a send file has been created which consists of heading JCL, two manuscripts, and the job termination or ending JCL. The file name created as the send file is SF0627 lAL and it consists of four subfiles:

1. JCLHFBAL
2. FB0201 201720l-06
3. FB020 2011414-12
4. JCLEBBAL

VIEWGRAPH #11

REMOTE JOB ENTRY COMMAND

RJE RF ;SF1 ;SF2

Send File 1

Send File 2

Receive File
(Autokon output)

EXAMPLE: RJE RF0627 IAL ;SF0627 lAL

VIEWGRAPH #12

SEND FILE STRUCTURE

SFØ627 1AL (filename)
JCLHFBAL
FBØ2Ø1 2Ø172Ø1-Ø6
FBØ2Ø1 2Ø11414-12 **(subfile names)**
JCLEBBAL

Both Bodies (common to both data bases)

Ending

(Refer to Viewgraph #l3)

The JCLHFBAL is the job control language which directs the host computer to execute the proper Autokon module with the correck database. FB0201 2017201-06 and FB020l 2011414-12 are the manuscripts which are to be executed. JCLEBBAL is the job control language which terminates this particular run.

VIEWGRAPH #13

TYPICAL- JOB STREAM

JCLHFBAL
(job control language)

```
@RUN BIW000,,CBJ000/GJ2UG6,15,100/1000
@COL FLD
@HDG  xxx  FFGFOLLOWSHIP FOREBODY ALKON  xxx
@ASG,AX ABS*VERC
@USE A.,ABS*VERC
@ASG,AX BIW*FBDATA
@USE 12.,BIW*FBDATA
@ASG,T  11.,F/100//900
@XQT  A.ALKON/BATH
FFGFOLL  FB
```

FB0201 2017201-06
(manuscript)

```
? COMM(#2017201-06#FWDxxx   JOB2017B    FACE PLT  1-OFF CL EBW)
PERML'
ON(KWC)
SPT'
MARK(21+61+O)          MARK(3F+lI+90)     MARK(7F+1I+90)
MARK(llF+lI+t+90)      MARK(15F+1I+90)    MARK(17F+lI+90)
MARK(19F+1I+90)        MARK(23F+1I+90)    MARK(27F+1I+90)
MARK:(28F81+.61+0)     MARK(27F+9I+90)    MARK(23F+9I+90)
MARK(19F+9I+9o)        MARK(17F+9I+90)    MARK(15F+91+90)
MARK(llF+91+90)        MARK(7F+9I+90)     MARK{3F+9I+90)
RAP:EPT'
SL:EPT(29F+0)
SL:EPT(29F+1F)
SL:EFT(O+lF)
SL:EPT'
END  LGEO'
FIN  BIWM(2O17201+06)
```

FBØ2Ø1 2O11414-12
(manuscript)

```
?  COMM(#2011414-12#FWEXXX  2011A  1  OFF  CL  JBB)
PLSURF50(5F5I+0+5F51+9F21+0+9F21+2011414+12)
```

JCLEBBAL
(job control language)

```
&
@FIN
@@
```

Supplementary Software

Bath Iron works functions without the use of paper tape or punched cards and as such software was developed to assist in operating without either of the above mentioned mediums. Editor software was developed for keyentry and verification. Commands available while in the edit mode are as follow:

{Refer to Viewgraph #14)

1. Delete
2. String Replace
3. File Read
4. File Write
5. Insert
6. Print
7. Verify

In addition to keyentry, verification, and editing of data, it is necessary to be able to manipulate files. File manipulation software which has been developed is commanded as follows:

EDITOR COMMANDS

Delete
String Replace
File Read
File Write
Insert
Print
Verify

FILE MANIPULATION COMMANDS

Catalog
Change
copy
Delete
Directory
List
Plot
Punch
Tape Duplication

1. Catalog
2. Change
3. copy
4. Delete
5. Directory
6. List
7. Plot
8. Punch
9. Tape Duplication

The PLOT command is used to direct the transfer of data to be plotted from disk storage on the RJE terminal to the plotter controller. This can be done for an entire file or any subfile within a file. If an entire file is plotted, several plots can be done consecutively with only repositioning of the plotter being necessary between plots.

FILE MANIPULATION

COMMANDS	SYNTAX	
CAT	CAT_/\$xx_Ø,xxxx Listing Device (optional); File Name	Catalog of a specific file - lists to CRT or optional device: subfile names and number of characters.
CHG	CHG_Ø, xxxx>Ø, xxxx Old File Name; New File Name	Change file name only - requests confirmation: enter 'Y' or cancel by carriage return.
COPY	COPY_Ø, xxxx>!Ø, xxxx File To Be Copied; No Entry = New File, + = Add, ! = Replace; Destination File	Copy one file to another - may be added to or replace destination file; either file ident. may be a peripheral device.
DATE	DATE_xxxx/xx/xx Year; Month; Day	Type DATE & carriage return to check, must be updated daily. To Sort by creation date: type DIR T.
DEL	DEL_Ø,xxxx File Name	Delete the file - requests confirmation: enter "Y" or cancel by carriage return.
DIR	DIR_/\$xx_Ø Listing Device (optional); Drive Ident.	Directory of a specific disk - if no disk is identified entire scratchpool directory will be listed.
DNC x	DNC x_Ø,xxxx Machine To Be Directed; File Name	Opens designated file to designated machine - at the completion of, or to terminate an operation Type: DNC x and carriage return to close file.
FORMAT	FORMAT_Ø,xxxx Drive Ident.; Disk Ident	Format a fresh disk and assign a disk ident. - ID may be any number from 1 to 32000.
LIST	LIST_/\$xx_Ø,xxxx#xxx# Listing Device (optional); File Name; Subfile Name (optional)	Lists the contents of a file with line numbers added by the system - may list to peripheral device.
PLOT	PLOT_Ø,xxxx File Name	Opens designated file to the plotter controller - at the completion of plot, the file must be closed by typing: PLOT and carriage return.
PUNCH	PUNCH_/BURN *xxxx*Ø,xxxx Burning Data Only (Optional); Operator Readable Title (optional); File Name	Punch Tape for plotter or burning machine use - titles (operator readable) may be added to leader.
SDRV	SDRV_Ø,1,2,3 Drive Ident. (any or all)	Assign specific drives to the scratchpool - existing scratchpool may be listed by SDRV and carriage return.
TDUP	TDUP	Connects Tape Punch to Tape Reader for duplicating tape - execution begins with carriage return.

REMOTE JOB ENTRY

COMMANDS	SYNTAX	
TEST	TEST_:xx; xxxx; xxxx Number of File Lines To List; Command File No. 1; Command File No. 2	Used to confirm RJE file order and content - specified number of lines from each file is listed for review.
RJE	RJE_/\$xx_xxx; xxx; xxx Print Data Device; Punch Data Device; Command Filename; Command Filename	Used to initiate a RJE transaction - terminal will respond with: ESTABLISH PHONE LINK. Call-up host and press data button.

OPERATIONAL MODE

The Bath Iron Works Numerical Control Center functions as a service organization to the Mold Loft and the Cutting Machine area. Manuscripts are submitted to the Numerical Control Center where they are processed in accordance with a unit schedule established by the Mold Loft. Manuscripts are keyentered or edited as the case may be and processed through the correct Autokon Module. When the manuscripts have been executed through the Autokon System and the output data plotted, all the information for that-manuscript is returned to the N/C programmers for verification. When parts verification, nesting and nest verification have been completed, the N/C Center prepares a floppy disk with all the data necessary for a given construction unit.

(Refer to Viewgraph #15)

Then a mylar plot is prepared which is sent to the Mold Loft where additional information is added. A copy cf the diskette is prepared and retained in the N/C Center and the other version is delivered

```
DIR 3

DIRECTORY  DRIVE  F3   Disk  1058
ENEF201      0 0 0 0   1978/6/2     11
BNEF201A     0 0 0 0   1978/6/2     11
BNEF201B     0 0 0 0   1978/6/2     11
BNEF201C     0 0 0 0   1978/6/2     11
BNEF201D     0o  0 0   1978/6/7     11
BNEF201E      0 0 0 0  1978/6/7     9
SHFB201      0 0 0 0   1978/4/27    11
SHFB201A     0 0 0 0   1978/4/27    11

8 ENTRIES.  SFACE USED 86 OF 219


O:CAT  3,BNEF201

BNEF201
                                  23
#BIW000  NC-1211-12  #            465
#BIW000  NC-1212-12  #            324
#BIW000  NC-1213-12  #            1261
#BIW000  NC-826-12  #             825
#BIW000  NC-166-12  #             970
#BIWOOO  NC-1219-11  #            1906
#BIW000  NC-212-11                2482
#BIW000  NC-121O-12  #            826
#BIW000  NC-274-03 #              2601


O:CAT  3,BNEF201A

BNEF201A
                                  22
#BIW000  NC-232-06 #              7951
#BIW000  NC-304-07 #              4401


O:CAT  3,BNEF20l

BNEF201B
                                  22
#BIW000  NC-193-03 #              607
#BIW000  NC-252-03 #              3560
#BIW000  NC-1225-06               1402
#BIWOOO  NC-824-06  #             2770
#BIWOOO  NC-202--06  #            3899
```

to Mold Loft personnel for forwarding to the Cutting Machine Area along with a copy of the Mylar plot.

Upon completion of the cutting of the information contained on a given diskette, the diskette is returned to the Mold Loft for retention until that unit is again scheduled for cutting. With the Mold Loft acting as the retention center, it ensures that any changes occurring prior to cutting a unit for another hull will be incorporated onto that unit's diskette.

General Results

The DNC System installed at Bath Iron Works has been functioning in a production environment since October of 1977. The results have been better than expected as evident by the following:

l Relofting Output

As of June 1978, BIW'S Mold Loft had relofted eleven (11) of the sixteen (16) major construction units on the FFG ships.

In addition, several miscellaneous units have also been relofted.

Ten (10) recently trained programmers, formally 1/10 scale loftsman, have accomplished this relofting effort.

- <u>production Output - Cutting Machine</u>

The new N/C cutting machine with plasma arc capability is now dedicated to producing the cut parts for the Navy FFG program. The new N/C plasma machine will cut at a rate of 175 ipm as compared to the previous telerex rate of 15-20 ipm. It should also be noted that as a result of plasma non-ferrous material is being processed through this machine in lieu of shearing or sawing.

l <u>Equipment Reliability</u>

- Cutting Machine - the amount of lost production time since December, 1977, as a result of cutting machine equipment failure or communications problems between the Hardings' Control Center and the cutting machine has been minimal. BIW did chose to cut with paper tape in lieu of directly from floppy disk on five (5) occasions. The use of paper tape was required as a result of initial communications problems between the control center and the cutting machine controller. This occurred when the amount of data to be transferred exceeded the cutting machine computer buffer

  Union Carbide has just recently revised the communications software to resolve this problem.

- Bath Control Center Equipment

This center has been functioning since October 1977 entirely in the DNC mode. The paper tape capability of this center has only been used to produce and verify the five aforementioned tapes and to test the System's paper tape capability.

In essence, BIW is extremely pleased with our present DNC system. BIW'S decision to use paper tape as only a back-up system has proven to be a good one!

A USER'S VIEW OF THE SPADES HULLOAD PROGRAM FOR SPECIFYING SHIP STRUCTURE

E. Eugene Mayer
Livingston Shipbuilding Company
Orange, Texas

As Engineering Hull Section Manager, Mr. Mayer is currently responsible for all engineering hull structural drawing development, N/C hulload coding, N/C development within shipyard and welding and hull structural standards development. He has 18 years experience in shipbuilding engineering spanning three shipbuilding concerns (Todd-Houston, Gulfport and Livingston) as drafting designer in all shipbuilding disciplines, drafting supervisor, assistant chief hull engineer and hull section manager.

INTRODUCTION

Livingston Shipbuilding is a medium to small shipbuilding complex that builds both conventional marine vessels and offshore drilling equipment. We have been involved with Numerical Control Lofting for over three (3) years and have built three (3) jack-up drilling rigs, two (2) drill ships, a Great Lakes products carrier and processed several industrial products, contracts with the N/C controlled burning machine.

The Engineering Hull Section is responsible for the loading of the data base with SPADES HULLAD program. This program defines the locations of decks, sight edges, longitudinal bulkheads and all structures that Comprise a marine vessel. This program is easy to implement and the Hull Section draftsmen are used as programmers for establishing this important part of the ship's data base.

HULLOAD MODULE

About three years ago I was called into the front office and told that I was chosen to participate in a new program called Numerical Controlled Lofting. Having been in shipyards for several years I knew what lofting was, but I had no previous knowledge of numerical control and being from engineering, what function I would have in relation to lofting. When told that the ultimate goal of N\C lofting was to automatically mark and cut ship parts out of steel, I was both amazed and curious. The next thing to do was to learn what this new system consisted of and exactly the role engineering would have.

N\C lofting is divided into four main parts; fairing the lines, defining the structural locations, generating the ship parts and nesting

hose parts on plates for marking and burning. The lines drawings are usually a function of the Engineering Design Section with input from the Hull Section concerning cant frame locations and additional frames for erection butts if required. The Hull Section with drawings sets the locations of hull structural item and it is only natural that the Engineering Hull Section be responsible for implementation of the N/C program that defines hull structures. Since the N/C system that Livingston chose was the SPADES (Ship Production and Design Engineering Systems) system, the particular name for the program that defines structural locations is called the HULLOAD program. Management felt that the N\C HULLOAD program should remain an Engineering Hull Section function rather than a loft function, as is the case in many other shipbuilding facilities.

The next problem to solve was how to implement this new system and who to choose for training in HULLOAD coding. We felt that our experienced draftsmen would be the best choice, since loading of hull structure into a data base is similar to defining structure locations on engineering drawings. The process of teaching our present staff of draftsmen would be easier than increasing our overhead specifically for computer oriented people who knew nothing about hull structures. The choice proved to be correct since the engineering people sent for training learned enough about HULLOAD coding in two weeks to become proficient enough for normal loading.

Of course, not everyone exposed to N\C coding can become proficient; however, out of the twenty plus people trained in our facility, only five percent are completely inapt with another fifteen percent limited

in their ability to fully code- SPADESN HULLOAD. This, of course, is not to say that our training procedure is that efficient, as it is actually a testament to the ease of the SPADES HULLOAD coding system.

The HULLOAD coding system developed by Cali and Associates is based on shipbuilding terms, or retire specifically abbreviations of shipbuilding terms. Such terms as DECK, CUTS, MANU and LINE are examples of the many such commands used for commands. Ah Engineering Hull Section draftsman has no trouble understanding the code words used with this system as for example, the code for longitudinal bulkhead is "LBHD".

The codewords of this system are not the only part of HULLOAD coding that is easy for the coder to understand. The center of the program is the coordinate system which is built around the same system the manual system uses. Heights, halfbreadths and longitudinal center of gravity as represented by the X, Y, and Z axis-are as common to shipbuilding as is port and starboard. As for *port,* that *is the* side that the structure is normally loaded to; but, as ships and marine equipment are not always symmetrical., the option to load differences between port and starboard exist and is easy to do.

In the SPADES SYSTEM of coding, there are four cards or coding lines that precede each program. These are the *JOB, INPS(input start), OPTN (options), and RMKS (remarks) commands. These commands set the conditions of loading such as the tape number, measurement system, load or no load and remain the same for each tape number loaded into the Data Base.

With this program. the easiest structrual items to load are the decks and longitudinal bulkheads. A flat deck and straight longitudinal bulkhead can be loaded with **only** a one card description each. Decks with shear and more commonly camber take a minimum of five cards with loading for shear taking the most because of the offsets required. Longitudinal bulkheads may be loaded in almost any configuration including different off centerline dimensions and sloped hopper type commonly used in cargo holds.

Defining shell, longitudinal bulkhead and deck traces are also easy to load; but due to the number of traces usually required on a marine vessel, it is time consuming. A seam or stiffener trace usually requires only three lines or cards for straight line loading and with new commands REFR (reference) and RLTV (relative) even less cards are required. The new commands load each trace parallel to a previous trace by the given increments. Also, for adjustments to traces after loading is complete, a single trace can be moved without disturbing other traces with the new * SLT (select) command. This command will also work for changing decks and longitudinal bulkheads.

Probably the most difficult to load and teach how to load is the cutout definition for stiffener notches. The reason for this difficulty is the number of different cutouts usually required for ships and the description consists of manual line and circle commands which require about seven cards each. The orientation of cutout loading is also a problem due to the numerous ways stiffeners can be positioned on a ship. Loading the stiffener size itself is done with the MEMB (member) and type commands. This series of commands loads the structural members and the type of notch required to its respective trace.

The SPADES HULLOAD program is priobably the best of such programs, but there are still some problems. For instance , there is a difficulty in loading sight edges to the extreme ends of a fine lined ship, but this can be implemented with manual manipulations of the input points. Another item that is causing some difficulty is the loading of additional frames or transverse lines in between frame spaces for such things as master erection butts. However, this too can be implemented by loading additional frames with the Lines Fairing Program. So, the only real problem that the program has left the user shipyard with is the inability offloading transverse bulkheads. Even this may soon become a possibility for SPADES Users.

NEW FEATURES IN HULLOAD

Due to be released are several new features for ease of HULLOAD coding, such as the use of a “RANGE” command for the laborious. coding of member type structural definition commands. The ability to override with the use of “Exclude" and “Include” features will be used in conjunction with commands like “RANGE” for dissimilarities in structure locations. New commands for HULLOAD that are now used in parts generation module are the "LOO", ’’REP” (repetition), SUB* (sub-input data set), “JUMP”, and logical “IF" commands all of which should ease the amount of coding required for each new,contract.

Another item that should help ease the amount of HULLOAD coding will be the ability to load a surface (deck or longitudinal bulkhead) relative to an existing trace or another surface. Also to be included in the next release will be the mathematical definition of flat surfaces such as deck

and bulkheads with straight sheer and/or camber, will be **stored on the** data base as part of the future surface control records.

THE FUTURE PROSPECTS FOR HULLOAD

The future of the HULLOAD module is very bright and will be the trend setter for all such programs. The SPADES HULLOAD module will shortly have the capacity of storing on the data base complete surface definitions for all decks, longitudinal and transverse bulkheads. Also **to** be stored on the data base for each defined surface are the traces of all intersecting surfaces including the shell and defined in the plan of the surface if flat or in the appropriate view plan, elevation, or transverse). To be stored for each appropriate surface will be the traces of all defined stiffeners (longitudinal, transverse, horizontal and vertical) seams and butts in the plan of the surface if flat or in the appropriate view (plan, elevation, or transverse).

In association with surfaces and traces on surfaces the structural shapes, details and associated cut-outs will be stored on the data base for each defined stiffener on each appropriate surface. The ranges of the definitions will be included so that at any location along the sur**face** stiffener, the stiffener type, size, detail and associated cut-out can be obtained from the data base. Plate thicknesses and associated clearance cuts will be stored for each defined seam and butts on each appropriate surface similar to as described above for stiffeners.

The loading of the data base for all crossing, intersecting or secondary surfaces or frames can be. preformed almost automatically with a minimum amount of input data given by utilizing all of the above

surface and detail data. This will also improve the cross-reference and integrity of the data base.

Before, with the lines fairing and the HULLOAD modules, a ship or marine vessel was a series of interconnecting lines composed of frames, decks, sight edges, waterlines, buttocks, etc., similar to a three dimensional wire line diagram. When the future plans for the HULLOAD module become reality, we not only have a wire type diagram, but also have the planes in between so that the computer ship now represents more fully the true ship shape and configuration.

We can only visualize the true meaning this has for the shipbuilding industry and the impact on engineering and lofting manhours. The updated SPADES HULLOAD program, in conjunction with a new SPADES module called "DEMO", will be able to produce engineering drawings that require only hand finishing for dimensions and notes. The future of Numerical Control Lofting, or should I say Numerical Control Engineering and Lofting, becomes very bright indeed.

ACKNOWLEDGMENTS

Jan Ulsteen of Cali and Associates for his contributions in regard to the new features and the future of the SPADES HULLOAD program.

APPENDIX

EXAMPLES OF SPADES' HULLOAD CODING

I. SPADES Coordinate System

II. Program Start Cards for Each HULLOAD Tape Number

III. Deck Coding Eamples

  A. Typical Example Coding Sheet

  B. Diagram of Example Coded Decks

  C. Typical Ship's File Report for Loaded Deck

IV. Longitudinal Bulkhead Coding Examples

  A. Typical Example Coding Sheet

  B. Diagram of Example Coded Longitudinal Bulkhead

  C. Typical Ship's File Report for Loaded Longitudinal Bulkhead

V. Trace and Member Description Coding Examples

  A. Shell Seam Example Coding

  B. Example cf HULLOAD Coding Print-out for Shell Stiffeners

  C. Example of Print-out with Error in Key Punching or Coding

  D. Example of Structure Loadinq Coding

  E. Ship's File Report for Shell Traces and Cut-out Numbers

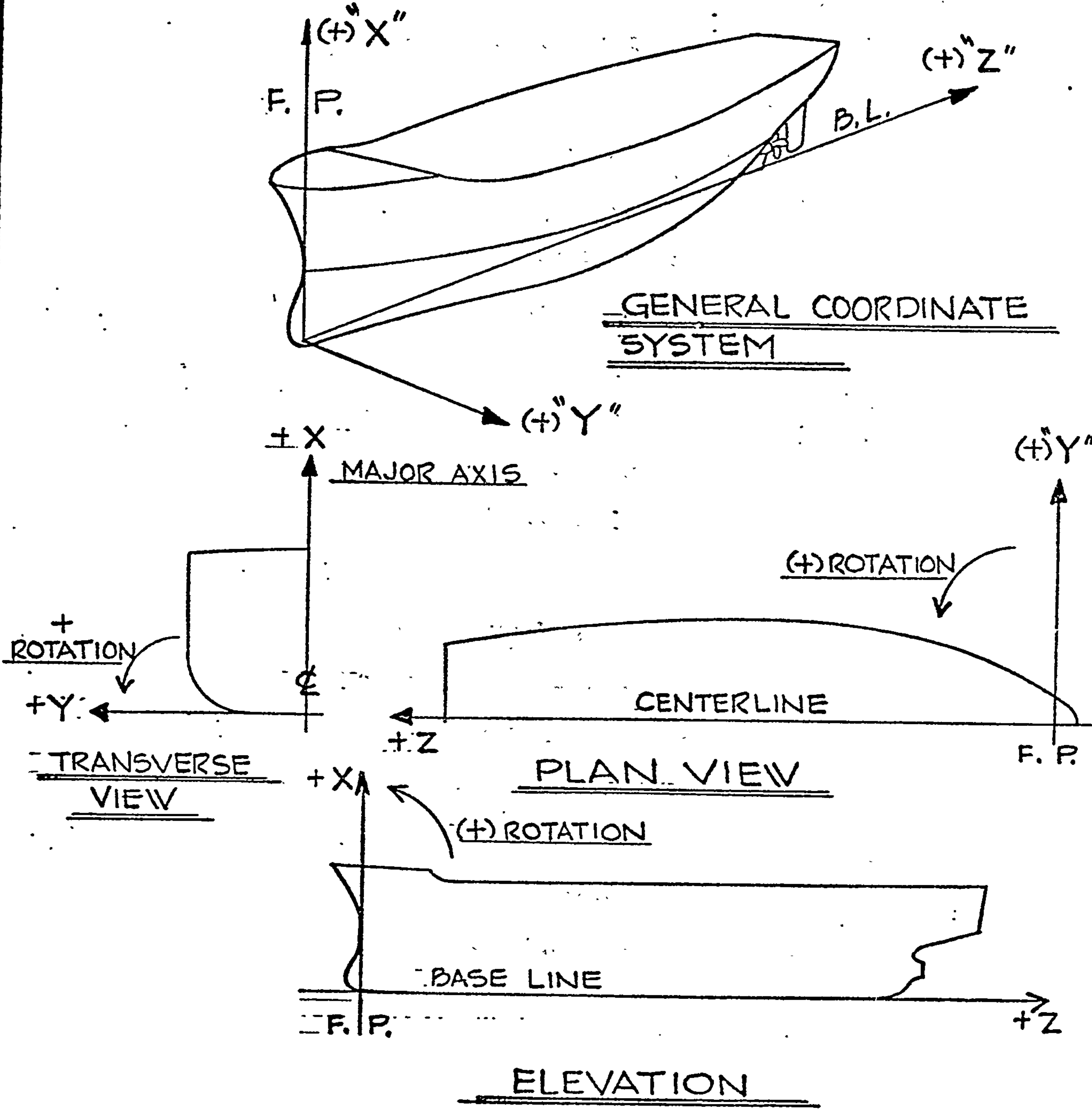
VI. Cut-out Coding Examples

  A. Cut-out Coding Sheet Example

  B. Diagram of Example Cut-out Coding

VII. HULLOAD Body Plan Example

REFERENCE AXIS AND VIEWS
HULLOAD PROGRAM



I.

SPADES SYSTEM INPUT DATA FORM

PROGRAM TYPICAL JOB CODING FOR EACH HULLOAD TAPE START   PROGRAMMER ______ DATE ______ PAGE ___ OF ___

COMMAND | ALPHABETIC INFORMATION (CODE, 2, 3, 4) | FIELD 1 (UNIT, FRAC., NAME) | FIELD 2 (UNIT, FRAC, NAME) | FIELD 3 (UNIT, FRAC, NAME) | FIELD 4 (UNIT, FRAC, NAME) | POINT FIELDS (1, 2, 3) | CARD ID (JOB NO, TAPE NO, SHEET NO, LINE NO)

*JØB LS03HULDCISK N 0001 ← TAPE NO   17 000101

TYPE OF INPUT (MAY NOT BE REQ'D IN LATEST RELEASE)

HULL CODE   PROGRAM CODE

JOB START COMMAND

LEVINGSTON JOB NO.

INPS N 0001 ← TAPE NO.

HULLOAD PROGRAM NO. (ALWAYS 17)

INPUT START COMMAND

ØPTN 16THLØADPRNT

OPTIONS FOR MEASUREMENT, LOADING, PRINTING & ETC.

OPTION COMMAND

THESE COMMANDS APPEAR ON EACH HULLOAD TAPE NO.

II.

SPADES SYSTEM INPUT DATA FORM

PROGRAM: HULLOAD DECK CODING   PROGRAMMER ______ DATE ______ PAGE ____ OF ____

COMMAND	ALPHABETIC INFORMATION (CODE, 2, 3, 4)	FIELD 1	FIELD 2	FIELD 3	FIELD 4	POINT FIELDS (1, 2, 3)	CARD ID (JOB NO, TYPE, TAPE NO., SHEET NO)	LINE NO
*JØB	SHIPHULDDISK	N 0002					17000201	00
INPS	16TH	N 0002						04
ØPIN	DRAWLØADPRNT	V 24						08
RMKS	SHIP DECK							12
	LØADING							16
SURF								20
DECK	MAIN DECK	DMDK		Z F -3	Z F169			24
ELEV		30	Z F -3					28
		30	Z F169					32
TRSV		0	0					36
		0	9 6		K			40
		-15	36					44
DECK2	19 FT FLAT	D19F	X 19	Z F 10	Z F 80			48
INPE							17000299 99	52
								56
								60
								64
								68
								72
								76
								80
								84
								88
								92

TYPICAL INPUT START INFO

LONG'L DESCRIPTION (FOR SHEER)

COMMAND FOR DECK W/CAMBER & SHEER

CAMBER DESCRIPTION

KNUCKLE POINT

COMMAND FOR FLAT DECK

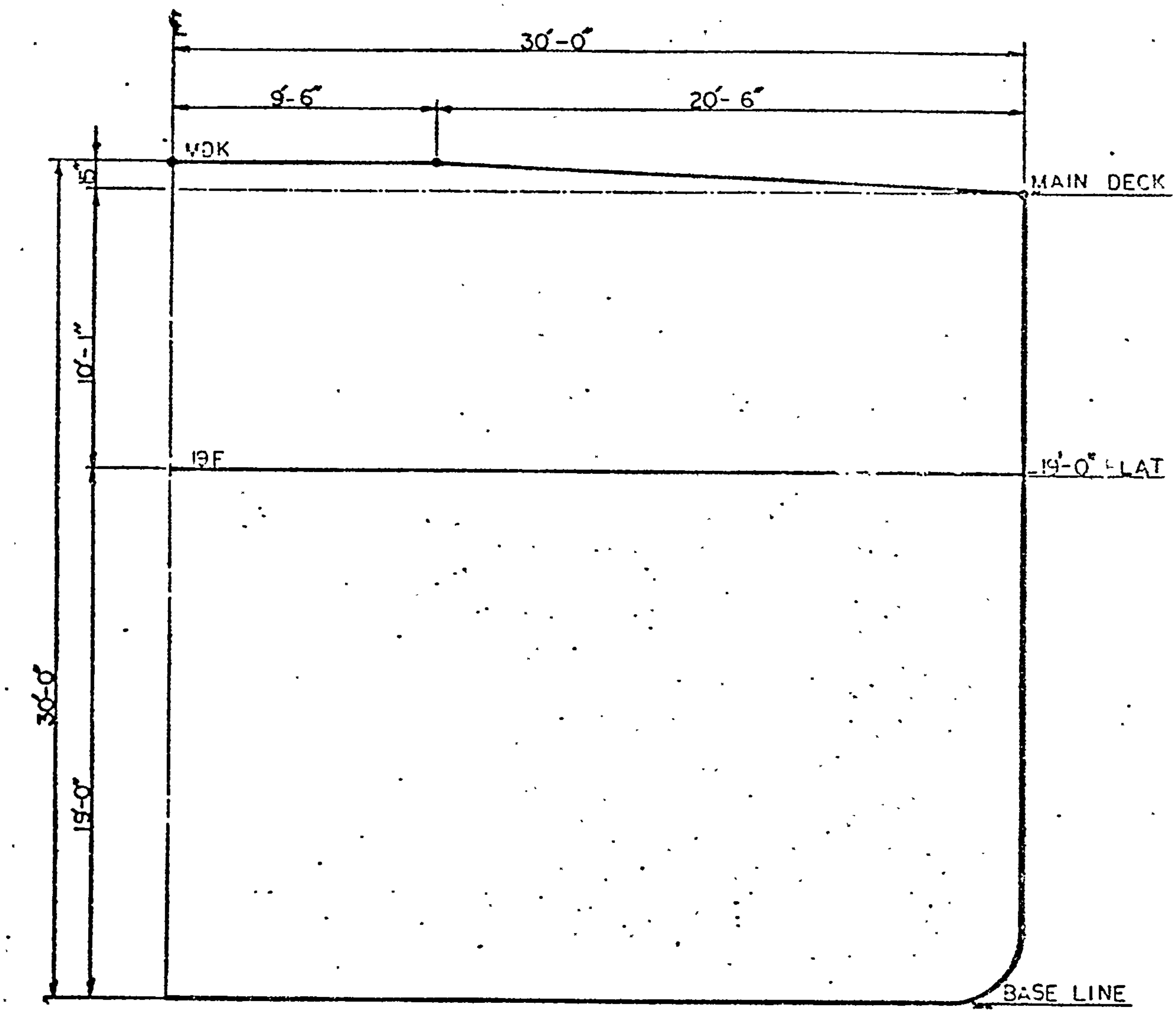
LONG'L RANGE

FEET

INCHES

16THS

III. A.



DECK LOADING EXAMPLE

III. B.

--- DECK TABLE ---

FRAME = 80000 LCG = 195.000 FRAME = 80000

RECORD LOADED 11/05/76 04/06/06 REV. 16

DECK TT		X	Y	ANGLE(DEGR)	SEG.AT SHELL
	STRT.PT.	3.000	0.0	90.000	
	END PT.	4.000	28.583	87.825	0

--- DECK CONTOUR ---

	INCREMENTAL COORDINATES					ABSOLUTE COORDINATES	
	X	Y	XC	YC	DIR	X	Y
1	0.0	2.250	-3.000	0.0		3.000	0.0
2	1.000	26.333	-3.000	-2.250		3.000	2.250
3	0.0	0.0	0.0	0.0		4.000	28.583

TOTAL NO. OF LONGITUDINALS-SEAMS = 19

	NAME	SEG	KN	ABSOLUTE COORDINATES X	Y	DX	DY	ORIENT.	TANGENT	CUTOUT NO.	MEMB NO.
LBHD.	CVK	1	0	3.000	0.0	*******	*******	0.0	90.000	100 NT	500
LONG	1	1	0	3.000	2.000	0.0	0.0	180.000	90.000	102 NT	500
SEAM	A	2	0	3.000	2.250	0.0	0.0	177.825 N	87.825	100 NT	500
LONG	2	2	0	3.078	4.292	0.0	0.0	180.000	87.825	-102 NT	500
LONG	2 P	2	0	3.078	4.292	0.0	0.0	177.825 N	87.825	100 NT	500
LONG	2 8	2	0	3.078	4.292	0.0	0.0	177.825 N	87.825	100 NT	500
LONG	3	2	0	3.165	6.583	0.0	0.0	180.000	87.825	-102 NT	500
LONG	4	2	0	3.252	8.875	0.0	0.0	180.000	87.825	-102 NT	500
LONG	5	2	0	3.339	11.167	0.0	0.0	180.000	87.825	-102 NT	500
SEAM	B	2	0	3.373	12.076	0.0	0.0	177.825 N	87.825	100 NT	500
LONG	6	2	0	3.426	13.458	0.0	0.0	180.000	87.825	-102 NT	500
LBHD	LSK	2	0	3.513	15.750	*******	*******	0.0	87.825	100 NT	500
LONG	7	2	0	3.600	18.042	0.0	0.0	180.000	87.825	-102 NT	500
LONG	8	2	0	3.687	20.333	0.0	0.0	180.000	87.825	-102 NT	500
SEAM	C	2	0	3.715	21.070	0.0	0.0	177.825 N	87.825	100 NT	500
LONG	9	2	0	3.774	22.625	0.0	0.0	180.000	87.825	-102 NT	500
LONG	10	2	0	3.861	24.917	0.0	0.0	180.000	87.825	-102 NT	500
LONG	11	2	0	3.948	27.208	0.0	0.0	180.000	87.825	-102 NT	500
SEAM	D	2	0	3.999	28.552	0.0	0.0	177.825 N	87.825	100 NT	500

RECORD LOADED 07/29/76 17/01/00 REV. 3

DECK 12F		X	Y	ANGLE(DEGR)	SEG.AT SHELL
	STRT.PT.	12.167	28.500	90.000	
	END PT.	12.167	32.500	90.000	3

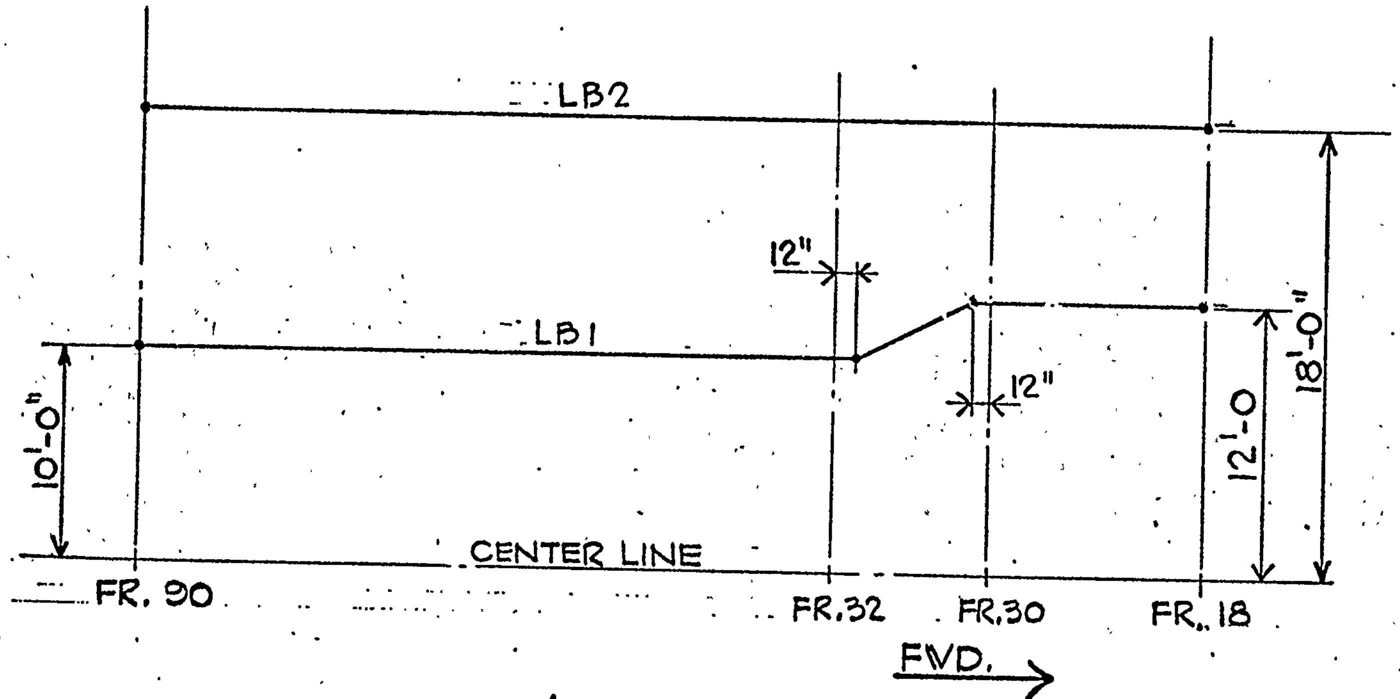
III. C.

SPADES SYSTEM INPUT DATA FORM

PROGRAM: HULLOAD LONG'L BULKHEAD CODING PROGRAMMER ________ DATE ________ PAGE ____ OF ____

COMMAND	ALPHABETIC INFORMATION (CODE, 2, 3, 4)	FIELD 1	FIELD 1 UNIT / NAME	FIELD 1 FRAC	FIELD 2	FIELD 3	FIELD 4	POINT FIELDS 1 2 3	CARD ID (JOB NO, TAPE NO., SHEET NO)	LINE NO
									1 7 0002 01	0
*JØB	SHIPHULODISK	N		0C02						04
INPS	1 16TH	N		0C02						08
ØPTN	NDRYLØADNPRT									12
RMKS	LONG BHD									16
	LOADING									20
SURF										24
LBHD	12 TO 10 OFF BHD		LLB1			Z F 18	Z F 90			28
PLAN			12		F 18					32
			12		F 30	H1	K			36
			10		F 32	-12	K			40
			10		F 90					44
TRSY			20	1	0					48
			5		0					52
LBHD2	18 OFF BHD		LLB2		Y 18	Z F 18	Z F 90		1 7 0002 99	99
INPE										

IV. A



LONG'L BULKHEAD LOADING
EXAMPLE

IV. B.

--- TABLE OF LONGITUDINAL BULKHEADS ---

FRAME = 60750 LCG = 3?2.000 FRAME = 60750

RECORD LOADED 02/10/76 21/10/19 REV. 10

LBHD 218

	X	Y	ANGLE(DEGR)	SEG.AT SHELL
STRT.PT.	1.079	21.500	0.0	
END PT.	35.448	21.500	0.001	2

--- LBHD CONTOUR ---

	INCREMENTAL COORDINATES X	Y	XC	YC	DIR	ABSOLUTE COORDINATES X	Y
1	34.368	0.0	-1.079	-21.500		1.079	21.500
2	0.0	0.0	0.0	0.0		35.448	21.500

TOTAL NO. OF LONGITUDINALS-SEAMS = 21

	NAME	SEG	KN	ABSOLUTE COORDINATES X	Y	DX	DY	ORIENT.	TANGENT	CUTOUT NO.	MEMB. NO.
LONG	1	1	0	3.000	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
DECK	TT	1	0	5.000	21.500	*******	*******	90.0??	0.000	100 NT	500
SEAM	A	1	0	5.750	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
LONG	2	1	0	7.000	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
LONG	3	1	0	9.000	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
LONG	4	1	0	11.000	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
LONG	5	1	0	13.000	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
LONG	6	1	0	15.000	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
SEAM	B	1	0	15.750	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
LONG	6A	1	0	17.000	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
LONG	8	1	0	19.000	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
LONG	9	1	0	21.000	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
LONG	10	1	0	23.000	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
DECK	UTD	1	0	25.000	21.500	*******	*******	90.000	0.000	100 NT	500
SEAM	C	1	0	25.750	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
LONG	12	1	0	27.000	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
LONG	13	1	0	29.000	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
LONG	14	1	0	31.000	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
LONG	15	1	0	33.000	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
SEAM	D	1	0	33.750	21.500	0.0	0.0	90.000 N	0.0	100 NT	500
DECK	MDK	1	0	35.448	21.500	*******	*******	91.768	0.000	100 NT	500

RECORD LOADED 02/10/76 21/08/28 REV. 15

LBHD 338

	X	Y	ANGLE(DEGR)	SEG.AT SHELL
STRT.PT.	25.000	33.000	0.0	
END PT.	35.093	33.000	0.0	0

IV.C.

SPADES SYSTEM INPUT DATA FORM

PROGRAM HULL LOAD TAPE #27 SHEL SEAMS AFT   PROGRAMMER [illegible]   DATE 8/25/76   PAGE 1 OF 3

COMMAND	ALPHABETIC INFORMATION	FIELD 1	FIELD 1 UNIT	FIELD 1 FRAC.	FIELD 2 NAME	FIELD 3	FIELD 3 NAME	FIELD 4	FIELD 4 NAME	CARD ID (JOB NO / TYPE / TAPE NO. / SHEET NO)	LINE NO
KJOF	_SO3HULDDISK	N		22						1 7 0022 00	00
INPS				22							04
OPTN	16TH										08
RMKS	SHEL SEAMS AFT										12
TRAC											16
SHEL		L									20
SEAM	STRAKE A	J	A			Z	F134	Z	F179		24
PLAN			3	9	F134						28
			5	9	F179						32
SEAM	STRAKE B	J	B			Z	F134	Z	F179		36
PLAN			11	9	F134						40
			11	9	F179						44
SEAM	STRAKE C1	J	C1			Z	F155	Z	F162		48
PLAN			17	9	F155						52
			17	9	F162						56
SEAM	STRAKE C	J	C			Z	F134	Z	F156		60
PLAN			19	9	F134						64
			19	9	F156						68
SEAM	STRAKE D	J	D			Z	F134	Z	F179		72
PLAN			27	9	F134						76
			27	9	F137			T			80
			27	1 2	F140						84
			25	3 8	F146						88
			21	1 2	F160						92

V.A.

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          1         2         3         4         5         6         7         8
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 INPUT UPDATING          DATE  12/28/76    TIME  19/10/51      RUN NO.    1
 JOB  LS03     PROG. HULD     INPUT ID.   26        REV. NO.   2         PAGE   1

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 OPTN DECFLOADPRNTDRAW                                                1700260108
 RMKS SHELL STIFF                                                     1700260112
      J A CAMPBELL                                                    1700260116
 TRAC                                                                 1700260120
 SHEL                      M                                          1700260124
 LONG                      S  1                                       1700260128
 PLAN                        2000    F134                             1700260132
                             2000    F140                             1700260136C
 LONG                      S  2                                       1700260140
 PLAN                        4292    F134                             1700260144
                             4292    F140                             1700260148C
 LONG                      S  3                                       1700260152
 PLAN                        6583    F134                             1700260156
                             6583    F140                             1700260160C
 LONG                      S  5                                       1700260164
 PLAN                       11167    F134                             1700260168
                            11167    F140                             1700260172C
 LONG                      S  8                                       1700260176
 PLAN                       20333    F134                             1700260180
                            20333    F140                             1700260184C
 LONG                      S 10                                       1700260200
 PLAN                       24917    F134                             1700260204
                            24917    F140                             1700260208C
 LONG                      S 11                                       1700260216
 PLAN                       27208    F134                             1700260220
                            27208    F140                             1700260224C
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 PLAN                       29500    F134                             1700260232
                            29500    F140                             1700260236C
 INPE                                                                 1700269999
          1         2         3         4         5         6         7         8
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                  SEVERITY = 0    INPUT IS STORED WITH REV. =   3

                                  INPUT IS EXECUTABLE
                        INPUT:   INPS                      N     0026

 OPTIONS IN EFFECT :      DECF - PRNT - NDRW - LOAD - FRAM -

                        INPUT:   OPTN DECFLOADPRNTDRAW

 OPTIONS IN EFFECT :      DECF - PRNT - DRAW - LOAD - FRAM -

 DRAWING TAPE NO.  :  170026 -   0   SCALE  1/  0.  : ORIGIN  X0 =     0.0
                                                              Y0 =     0.0
                                                              Z0 =     0.0

                        INPUT:   RMKS SHELL STIFF
                        INPUT:        J A CAMPBELL
                        INPUT:   TRAC
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V. B.

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                                   TRAC                                                                17   26 120
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                                                              2000    F136                             17   26 136
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                                                              6583    F136                             17   26 160
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                                   PLAN                     11167     F134                             17   26 168
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                                   PLAN                      24917    F134                             17   26 204
                                                             24917    F136                             17   26 208
                                   LONG                                                                17   26 212
                                   PLAN                   S  11                                        17   26 216
                                                             27208    F134                             17   26 220
                                                             27208    F136                             17   26 224
                                   LONG                   S  12                                        17   26 228
                                   PLAN                      29500    F134                             17   26 232
                                                             29500    F136                             17   26 236
                                   INPE                                                                17   269999
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368

V.C.

SPADES SYSTEM INPUT DATA FORM #32

PROGRAM MEMBER & TYPE -TAPE #32 PROGRAMMER ______ DATE 11-11-76 PAGE 1 OF 1

COMMAND	ALPHABETIC INFORMATION (CODE / 2 / 3 / 4)	FIELD 1 (UNIT / FRAC / NAME)	FIELD 2 (UNIT / FRAC / NAME)	FIELD 3 (UNIT / FRAC / NAME)	FIELD 4 (UNIT / FRAC / NAME)	POINT FIELDS (1 / 2 / 3)	JOB NO	TAPE NO.	SHEET NO	LINE NO
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INPE		0032								04
ØPTN	16THLOADPRNT									0[illegible]
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TYPE			N -101							16
MEMB		M	S 2	Z F 17	Z F 35					20
TYPE			N 101							24
MEMB		M	S 3	Z F 17	Z F 35					28
TYPE			N 101							32
MEMB		M	S 5	Z F 17	Z F 35					36
TYPE			N 101							40
MEMB		M	S 6	Z F 17	Z F 35					44
TYPE			N 101							48
MEMB		M	S 7	Z F 21	Z F 35					52
TYPE			N 101							56
MEMB		M	S 8	Z F 23	Z F 35					60
TYPE			N 101							64
MEMB		M	S 10	Z F 29	Z F 35					68
TYPE			N 101							72
MEMB		M	S 11	Z F 35	Z F 35					76
TYPE			N 101							80
INPE							17	0032	[illegible]	[illegible]
										88
										92

V.D.

--- TABLE OF TRACES ---

FRAME = 82000 LCG = 200.000 FRAME = 82000

RECORD LOADED 11/23/76 00/14/27 REV. 15

TOTAL NUMBER OF SHELL TRACES = 27

	NAME	SEG	KN	ABSOLUTE COORDINATES X	Y	DX	DY	ORIENT.	TANGENT	CUTOUT NO.	MEMB. NO.
LBHD	CVK	1	0	0.0	0.0	*******	*******	0.0	90.000	100 NT	500
STRG	CL	1	0	0.0	0.0	0.0	0.0	-0.000 N	90.000	100 NT	500
STRG	1	1	0	0.0	2.000	0.0	0.0	-0.000 N	90.000	-101 NT	500
SEDG	A	1	0	0.0	3.750	0.0	0.0	180.000 N	90.000	100 NT	500
STRG	2	1	0	0.0	4.292	0.0	0.0	-0.000 N	90.000	101 NT	500
STRG	3	1	0	0.0	6.583	0.0	0.0	-0.000 N	90.000	101 NT	500
STRG	4	1	0	0.0	8.875	0.0	0.0	-0.000 N	90.000	101 NT	500
STRG	5	1	0	0.0	11.167	0.0	0.0	-0.000 N	90.000	101 NT	500
SEDG	B	1	0	0.0	11.750	0.0	0.0	180.000 N	90.000	100 NT	500
STRG	6	1	0	0.0	13.458	0.0	0.0	-0.000 N	90.000	101 NT	500
LBHD	LSK	1	0	0.0	15.750	*******	*******	0.0	90.000	100 NT	500
STRG	7	1	0	0.0	18.042	0.0	0.0	-0.000 N	90.000	101 NT	500
SEDG	C	1	0	0.0	19.750	0.0	0.0	180.000 N	90.000	100 NT	500
STRG	8	1	0	0.0	20.333	0.0	0.0	-0.000 N	90.000	101 NT	500
STRG	9	1	0	0.0	22.625	0.0	0.0	-0.000 N	90.000	101 NT	500
STRG	10	1	0	0.0	[illegible]	0.0	0.0	-0.000 N	90.000	101 NT	500
STRG	11	1	0	0.0	27.208	0.0	0.0	-0.000 N	90.000	101 NT	500
SEDG	D	1	0	0.0	27.750	0.0	0.0	180.000 N	90.000	100 NT	500
STRG	12	2	0	0.0	29.500	0.0	0.0	-0.000 N	90.000	101 NT	500
SEDG	E	3	0	4.000	32.500	0.0	0.0	90.000 N	0.0	100 NT	500
SEDG	F	3	0	11.000	32.500	0.0	0.0	90.000 N	0.0	100 NT	500
DECK	12F	3	0	12.167	32.500	*******	*******	-90.000	0.0	100 NT	500
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DECK	19F	3	0	19.750	32.500	*******	*******	-90.000	0.0	100 NT	500
SEDG	H	3	0	25.000	32.500	0.0	0.0	90.000 N	0.0	100 NT	500
DECK	MDK	3	0	29.000	32.500	*******	*******	-88.107	0.0	100 NT	500
SEDG	J	3	0	29.750	32.500	0.0	0.0	90.000 N	0.0	100 NT	500

FRAME = 83000 LCG = 202.500 FRAME = 83000

RECORD LOADED 11/23/76 00/14/28 REV. 15

TOTAL NUMBER OF SHELL TRACES = 27

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STRG	CL	1	0	0.0	0.0	0.0	0.0	-0.000 N	90.000	100 NT	500
STRG	1	1	0	0.0	2.000	0.0	0.0	-0.000 N	90.000	-101 NT	500
SEDG	A	1	0	0.0	3.750	0.0	0.0	180.000 N	90.000	100 NT	500
STRG	2	1	0	0.0	4.292	0.0	0.0	-0.000 N	90.000	101 NT	500

V.E.

SPADES SYSTEM INPUT DATA FORM

PROGRAM: CUT OUTS PROGRAMMER: T. PROGRAMMER DATE: 6-17-78 PAGE 1 OF 1

COMMAND		ALPHABETIC INFORMATION (CODE, 2, 3, 4)		FIELD 1 (UNIT, FRAC / NAME)	FIELD 2 (UNIT, FRAC / NAME)	FIELD 3 (UNIT, FRAC / NAME)	FIELD 4 (UNIT, FRAC / NAME)	POINT FIELDS 1	POINT FIELDS 2	POINT FIELDS 3	CARD ID: JOB NO.	TAPE NO.	SHEET NO.	LINE NO.
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INPS			N	8										
ØPTN		16THLØAD												
RMKS		HULLJ45HOTCHES												12
CUTS		NT	N	102										16
SIZE				1 8	-5	9 4L	1 8R							20
MANU				7 4	-5									
CIRC	4			9 4	-4	1	+							28
LINE	1			9 4	-1									32
CIRC	4			7 4	0	1	+							36
LINE	1			1 8	0									40
INPE											1	70008	99	[illegible]
														48
														52
														56
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														68
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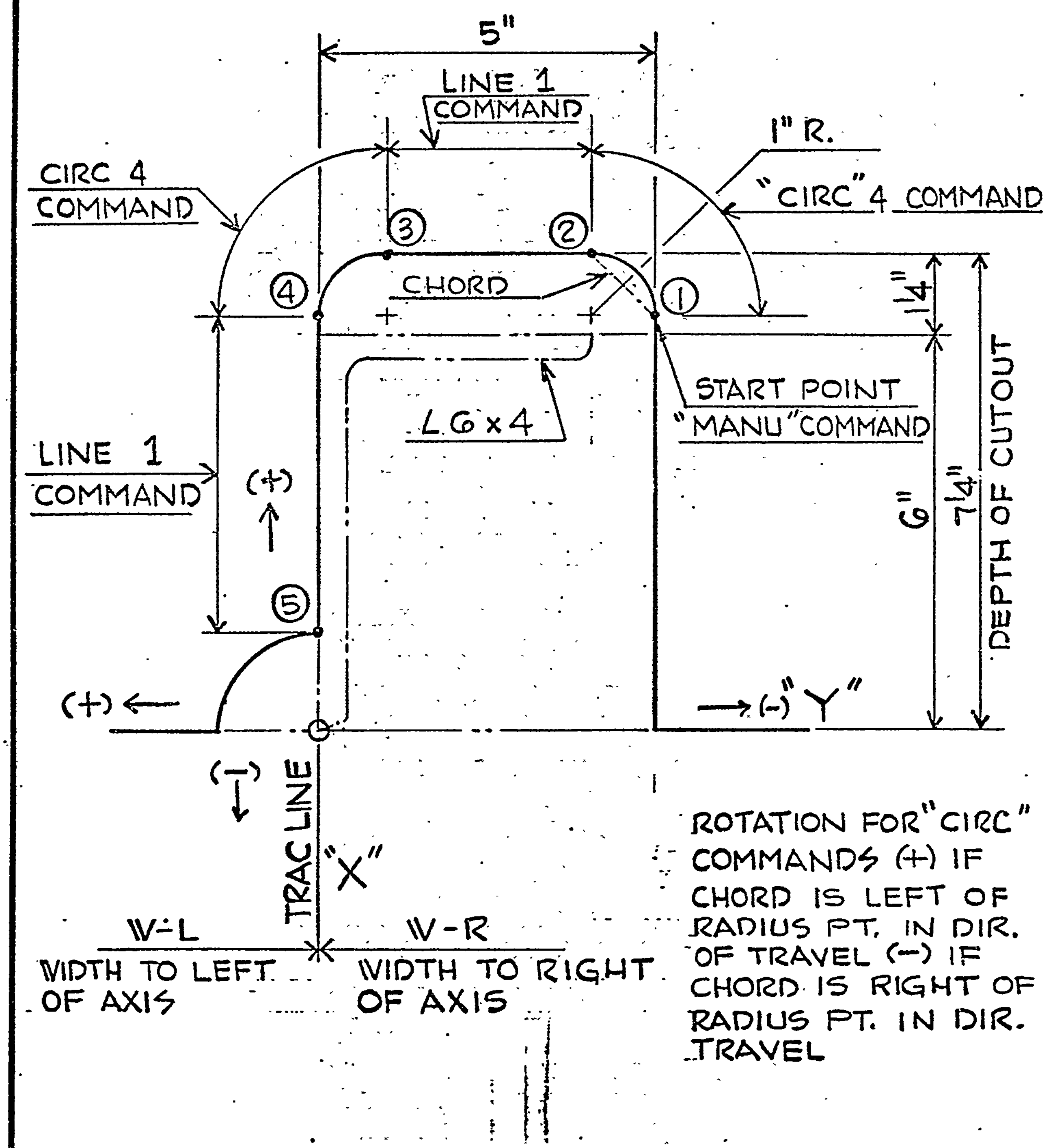
														76
														80
														84
														88
														92

VI.A.



HULL STRUCTURAL STANDARD TITLE	
TYPICAL N/C CUTOUT	
LEVINGSTON SHIPBUILDING CO.	STD. NO. / DATE / SHT. NO. / ALT NO

VI. B.

STEEL HANDLING AT NATIONAL STEEL AND SHIPBUILDING COMPANY

Lee E. Hoffman
National Steel and Shipbuilding Company
San Diego, California

Mr. Hoffman is Supervisor of Material Handling in the Division of Production Control over approximately 75 people. His primary responsibilities are to assist and direct material movement (work-in-process); maintain W-I-P storage; kit or stage assembly packages; order/receive material at assembly, erection, outfitting; and follow-up, liaison concerning material (late work, rework, plan changes).

Mr. Hoffman has a B.S. degree in industrial management from the University of Cincinnati, and a certificate in systems management from U.C.S.D.

Charles W. Jensen
National Steel and Shipbuilding Company
San Diego, California

As Manager of Production Control, Mr. Jensen is responsible for planning, scheduling, material handling, and expediting. He has a B.S.E. degree in naval architecture and marine engineering from the University of Michigan and a M.S. degree in management from Rensselaer Polytechnic Institute.

STEEL HANDLING AT NASSCO

The Problem

Managers in manufacturing or fabrication work know that material handling is expensive and most of them complain about it. Even though in some applications, estimates reach as high as 50, 60 and 70 percent, those managers who complain most bitterly may not know just how expensive it is because the reference is usually only to those costs directly attributable to the handling itself; that is, wages for material handlers, perhaps wages for expediters and the costs of storage and handling equipment and rolling stock. Not taken into account is the cost of a production crew which may be waiting for material or waiting for crane service or waiting for work space or spending time doing the same machine set-up two times for partial batches, and so on and so on. If these people are Shipfitters, Welders and Burners, they do not charge their time to material handling, they charge to shipfitting, welding and burning. No work has been accomplished but the meter is running. As a secondary consideration, a lot of people are getting frustrated and that probably also adds to costs.

The Attack

National Steel and Shipbuilding Company completed major programs of expansion and modernization in 1968 and 1975. Having entered into major oceangoing ship construction in 1958, it is now the largest ship construction facility in the Western United States. Objectives of these programs were:

1. Increase working real estate.
2. Maximize output from a plant which would still have severe space restrictions.

3. Minimize production costs through effective work area arrangement and installation of an automated steel handling system.

In 1958, NASSCO's land area was less than 40 acres. In 1968 it was expanded to 60 acres. At present, we operate on 72 acres of land with a total lease of 126 acres including water area. There are three building ways (96 X 675 , 115 X 905 , and 115 X 906) and a building basin (1,000' X 176') which can accommodate a tanker design of approximately 200,000 deadweight tons. In each of the modernizations, the rationale was to balance priorities and compromise as necessary to give full consideration to the following:

1. Determine best mix of modular assembly and pre-outfitting with panel-type construction.
2. Modernize and upgrade some existing facilities in place.
3. Improve work flow patterns and handling systems in steel fabrication and assembly.

Justifying Steel Handling Investment

The cost of our automated steel handling system at NASSCO was justified through assessment of both the direct and the indirect effects of material handling methods on total production cost. It was easily apparent that with more efficient physical movement of material and with effective administrative control of that physical movement, we could increase productivity through:

- Reduced direct material handling cost.
- Reduced idle time of production workers.

Steel Handling System

The area of modernization representing the greatest departure from traditional methods was the installation of an integrated, centrally controlled system for the

handling of shipbuilding steel from receipt of material through subassembly. A well-planned and centrally controlled handling system can achieve benefits similar to continuous process manufacturing. This both enables and demands a high order of production planning at the detail level. The objective of the detail planning and the rapid, mechanized handling is to increase product through-put per unit of time and unit of labor applied.

The conceptual strategy for the mechanized steel handling system was to achieve the desired capacity by moving steel rapidly, continuously, sequentially and along pre-selected lines.

Rapidly

Reduce time in transit, increase time in production.

Continuously

When material is moved, move it without intermediate stops and without re-handling.

Sequentially

Reduce shuffling and work station storage by providing for fabrication operations to be accomplished in reasonable sequence of geography and time.

Pre-selected Lines

Based on proper sequencing, arrange for material to be routed for automated transfer from work station to work station.

In converting concept to reality, the steel handling system was designed to best serve existing Plate Shop and Subassembly areas (Figures 1, 2, 3). This was an important distinction as opposed to building a complete new facility. In development of a system for our existing, working shipyard, goals were necessarily

tempered by the necessity to hold rearrangement of existing facilities to a reasonable minimum so as not to overly obstruct ongoing operations. The goal of improved material flow required incorporation of new equipment and existing equipment into an arrangement approaching optimum linear flow patterns. As you can imagine, the period of physical transition was most trying. However, we are quite satisfied that the result was worth the pain and suffering. Two important new prefabrication capabilities were added concurrent with installation of the steel handling system:

Flame Planer - edge preparation of plate and stripping of plate.

Beam Welder - fabrication of welded shapes from stripped plate.

Flow Pattern and Equipment

NASSCO's steel plate storage yard consists of approximately two acres of land, a 15 ton bridge gantry crane and a railroad spur (Figure 4). We can conveniently store approximately 40,000 tons of steel plates, and probably work with up to 100,000 tons, if necessary. We operate with about 300 separate piles of different size plates (many mixed). We average about 20 railroad cars and five truck loads of incoming steel per week for an average of 1,650 tons or about 800 plates per week. Our busiest week to date caused us to process 30 rail cars and 3,700 tons of plate.

The 15 ton bridge crane is a VIA NOVA installed in 1975. It has a rail span of 170' and a working beam of 230'. It can stack and unstack plate piles up to 12 feet.

The steel plates are received primarily by rail car. NASSCO justified installation of a new rail spur by showing a 30% saving of transportation cost over trucking plates. Our primary supplier is Kaiser Steel of Fontana (Los Angeles). The primary reason for still shipping some steel by truck is that immediacy of need sometimes coincides with a rail car shortage at the steel mill.

Once steel has been received, the standard operating procedure is for the Control Tower (staffed by Production Control personnel) to start the steel handling system with an order for a specific plate to be delivered, via a Wheelabrator, to a burning machine operation, an automated panel line, or directly to an assembly work station. The steel yard crane loads all plates and shapes to the Wheelabrator for peen blasting to remove mill scale prior to any fabrication operations. Since there is no back up to the single steel yard crane, we normally back-stack, or stage, the next 24 hours worth of plate ahead of the production operations in order to prevent production stoppage due to a breakdown of the crane. Limited in-process storage areas and dynamic production needs prevent us from staging even more material away from the steel yard.

As mentioned above, the first production work station for steel is the Wheelabrator. It provides a surface "peen" blast to remove mill scale, and can apply a primer coat of paint if the material is destined to go directly to erection. The Wheelabrator can blast at an average of ten lineal feet per minute and thus prepares a standard 10' by 38' plate in about four (4) minutes. At the present time this would be our restricting or bottleneck factor if we were to schedule more than an average of 2,000 tons of sub-assembled steel per week. This first production work station is built into the automated handling system, being fed and relieved by the conveyor system which carries forward to the other work stations.

The automatic conveyor system consists of four (4) elements:

1. Roller tables.
2. Beam tables.
3. Transfer cars (3).
4. Collocator system (VIA NOVA) including two collocator cars.

The prime mover of the conveyor system is the automatic collocator cars and their tracks (Figures 5, 6, 10, 11). The cars (2) run up to a speed of 100 Ft/minute on two different track systems, one of 800 feet, the other of 1,000 feet. The conveyor system can run in three different modes:

1. Central Automatic Control.
2. Local Automatic Control.
3. Local Manual Control.

The most frequent mode is Central Automatic Control, which is operated by a console operator in the Control Tower (not unlike a small airport control tower -- elevated, with a 360° view of all systems). The pre-planned automatic sequencing is carried out on mechanical instruction by the console operators. The operator simply enters instructions of where to move the material. The Collocator system automatically analyzes and reacts to the conditions of the system, such as:

1. Transfer car or table already loaded.
2. Magnetic crane beam in collocator track.
3. Slow speed at start up.
4. Delay at crossings.
5. Siren when car is in motion.

The cars do not have cables connected for their power, but use crane type conductors and collectors.

The overall system is designed to handle plates up to 10' x 39' long. It can handle a 41' plate in the manual mode. Due to the space limitations and alignment of the existing facilities, there are two rotating roller tables to load and transfer the plates, in addition to the three transfer cars that work on an axis perpendicular to the collocator system (Figures 5, 10). The transfer cars are used to load the various burning machines, panel line, or production areas.

As stated, the total conveyor system consists of the steel yard crane, Wheelabrator, and collocator cars with 1,800 feet of track. Assuming the system to be empty of work-in-process, we could replace a defective plate at a sub-assembly table in less than ten (10) minutes, even though it would travel nearly one-half mile and require two crane lifts, three transfer car moves, and two collocator car trips.

The conveyor system routinely feeds two production tables, a panel line and seven (7) burning machines. The burning machines at NASSCO are:

1. CM 150 N/C Plasma Shape Cutting Machine, which can cut plates at 100" per minute, up to 1" thick. It cuts at a temperature of up to 40,000° on a shallow bed of water to reduce pollutants (Figure 7).
2. CM 100 Gas Stripping Machine.
3. CM 70 N/C Tape Driven Shape Cutting Machine.
4. (2) CM 60 Shape Cutting Machines.
5. CM 56 Shape Cutting Machine.
6. Flame Planer.

The conveyor system also directly feeds our Tee-Beam welder (Figure 9), and a plate roll for plates up to 40' wide, 2" thick.

<u>Benefits To Handling From Standardization</u>

Reduction in steel handling costs can be derived in other ways than simply employing better and faster handling systems. As an example of this, we at NASSCO examined our design and nesting practices relative to minimizing ship weight and minimizing generation of scrap steel. Commencing with a complete listing of plate sizes and their applications in ships about to be built, we did a study which showed that in exchange for acceptably small increases in

ship weight and steel scrap, we could significantly reduce the number of different stock numbers to be used -- and therefore to be stored. Considering our limited steel storage area, fewer stock numbers directly converted to fewer mixed piles. This, in turn, meant cost reduction through less multiple handling. It is worth mentioning that there were also beneficial effects for Engineering and Purchasing as well as for the Steel Mill.

The method used in the standardization exercise was to produce a computer listing of all stock plates for one ship of one class. The list was in order of grade, thickness, width and length and also showed plate weight and quantity required. Successive efforts at combining near-like plates were performed through eight iterations with each listing having a reduced number of plates from the one before. At that point a decision was made that further increase in ship weight would be unacceptable.

The result of the standardization effort was a reduction in stock numbers of approximately 50 percent and steel weight increase of about 3 percent. A tabulation of the successive cuts is shown below:

Run No.	Total Stk. No's	Reduction in Stk. No's	Total Wt. Plates (Lbs)	Increased Wt. (Lbs)	% Wt. Increase
0	847	0	29,497,311	14,880	0
1	747	100	29,563,676	66,365	.225
2	656	191	29,609,266	111,955	.38
3	609	238	29,644,510	147,199	.50
4	551	296	29,718,558	221,247	.75
5	508	339	29,802,423	305,112	1.03
6	445	402	29,969,840	472,529	1.60
7	420	427	29,993,135	495,824	1.68
8	362	485	30,458,759	961,448	3.26

Similar studies were done on other ship classes under contract and on shapes and bar stock. The overall reduction in stock numbers was on the order of one-third.

Control Tower

The heart and nerve center of NASSCO's steel handling system is the Control Tower and the detail planning of manufacturing operations -- work station by work station. Within the Control Tower is the push-button console where the operator directs the system with electric signals and continuously monitors the system by means of a graphic status display (Figure 12).

The major portion of this system (collocator, transfer cars, Tower) was designed and built in 1968. In 1975 the yard acquired more land in order to move the steel yard to its present location and installed the steel yard crane and additional collocator run. Based upon data from SPARDIS (Scheduling, Planning and Reporting Data Information System), the "Tower" starts and directs all movement of raw steel (plates and shapes) into production. As dictated by schedules and daily, computer-generated priority lists, Production Control personnel manning the Tower routinely:

1. Order material to be delivered to production, via Wheelabrator.
2. Schedule, load/unload all burning machines.
3. Schedule, load/unload Tee-Bar welder.
4. Schedule, load/unload panel line.
5. Schedule and release all erection unit assemblies to the platens (based on master schedule and material availability).
6. Update/record all reported progress of burning machines and platens. This is done via teleprocessing terminals through an on-line computer system.
7. Provide feedback to the various planning groups pertaining to recommended or necessary "field" changes or material shortages.

In reality, the Tower and other Production Control personnel provide to platen supervision the proper schedule information and material availability status. It is normally done by a two part, daily, computer-generated report called:

1. Laydown Work Scheduled in Priority Sequence.
2. Sub-Assembly Work Scheduled in Priority Sequence.

This report prioritizes and lists all assemblies either not yet started or in-process. The priority is dynamic and is based upon erection schedules. The priority can be changed on-line overnight by authorized Production Control personnel. We normally schedule sub-assembly completion approximately six weeks prior to erection need. This allows significant leeway by the platen supervision to best utilize their assets (manpower, table space, hardware). At any given time, we usually have 50 to 100 assemblies ready to start, listed in erection priority. All raw material and manufactured components must be available in inventories maintained and controlled by Production Control or at least be in-process prior to release of the erection unit to the Platen.

Related Facilities

The platens (or sub-assembly) consists of eight different tables with a total area of 123,500 square feet, or 2.8 acres of working area. The Platens, Shops, Erection and Outfitting areas are serviced by 49 different cranes. Some of these cranes were built as long ago as 1939, and represent 14 different manufacturers, which of course is a major challenge to the cross training of operators and maintenance support. Included are:

12 "Whirley" gantries (45 to 175 ton capacity).

6 Mobile Cranes

6 Magnet Cranes

Panel Line

NASSCO's four station automated panel line was designed to assemble panels up to 40' by 65'. The movement of the steel plates and panels is accomplished by power driven friction wheels and continuous chains strategically located in the bed of roller chocks. Except for the turning over of panels, the alignment and movement of panels can be controlled by a single operator. An eight hour shift can produce five panels of six plates each. The limiting factor is welding time governed by plate thickness. The operating stations are:

#1 Tack Welding of Plates

#2 First Side Welding (Submerged Arc)

#3 Turn Over, Second Side Welding (Submerged Arc)

#4 Lay-Out of Panel

Frame-Bender

In 1979 we expect to have our new "frame-bender" installed and operating. This N/C controlled innovating design is capable of cold shaping beams, with webs up to 25" deep by 42' long, within a tolerance of ± 1/4" for total length.

Conclusion

In constructing a San Diego Class tanker, the steel we handle can be represented roughly as follows:

30,000 tons made up of:

10,000 plates

5,000 shapes

2,000 miscellaneous items

1,000 erection assemblies made up of:

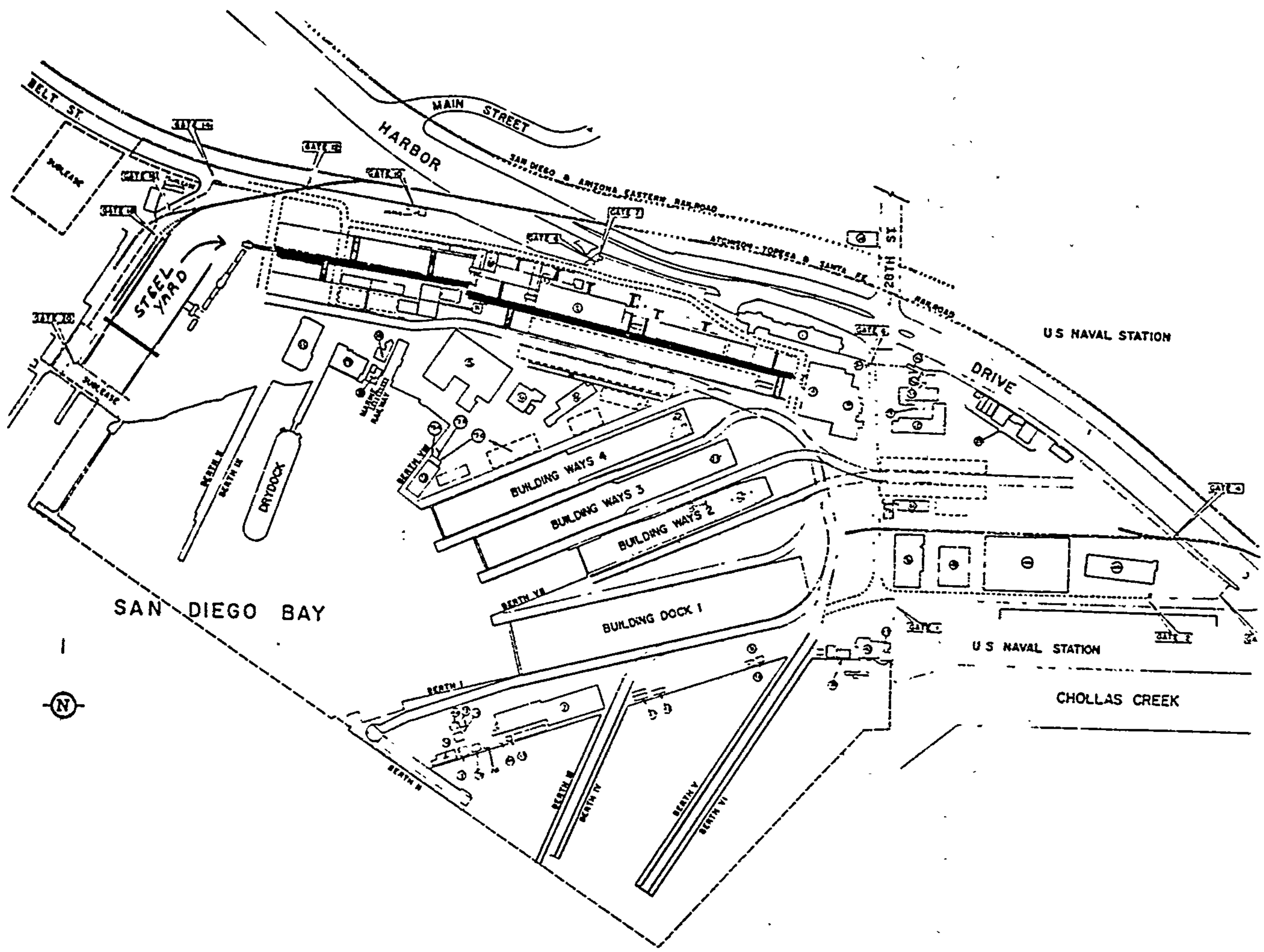
14,000 subassemblies

18,000 piece parts

750 tons of weld rod

The most satisfying move to most of us is when we handle it all in one piece.

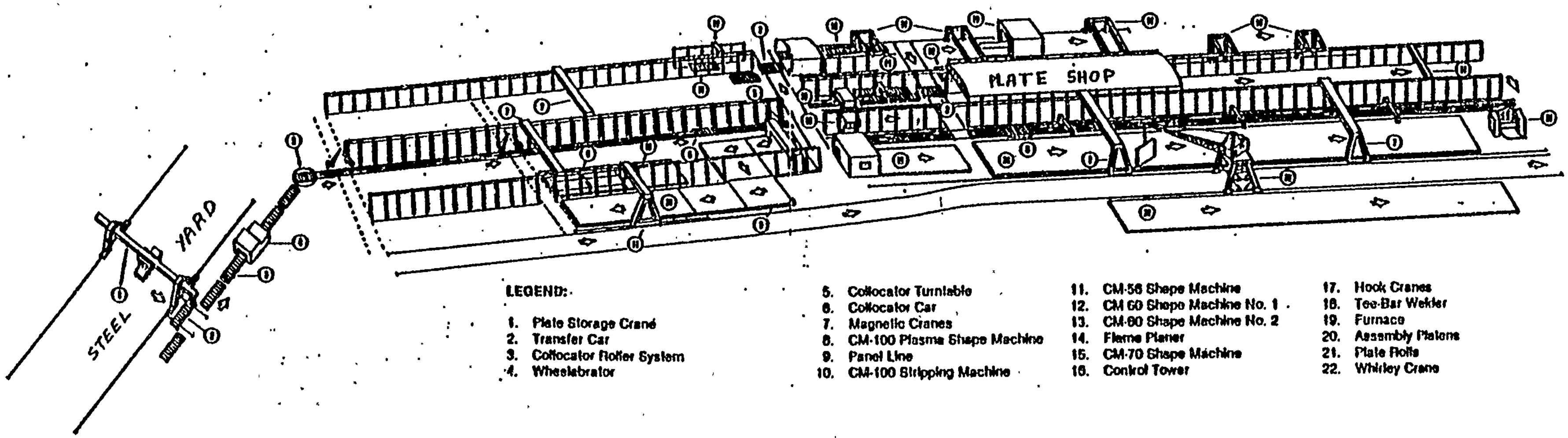
YARD LAYOUT



LEGEND

1 ADMINISTRATION
2 PLATE SHOP
3 GALVANIZING
4 PIPE SHOP
6 ELECTRIC SHOP
7 SHEET METAL SHOP
8 MACHINE SHOP
9 FOUNDRY
10 COMPRESSOR 2200 CFM
11 STOREROOM
12 MAINTENANCE
13 MACHINIST BULL PEN
14 OUTFITTING OFFICE
15 STORAGE SHACK
17 PAINT DIVISION
18 BY WAYS REPAIR & LOCKERS
19 CARPENTER SHOP
20 WELD REPAIR OFFICE
22 GRIT BLAST DIVISION
23 WASHROOM WOMEN
24 WASHROOM MEN
26 TEMPLATE STORAGE
27 MEN'S RESTROOM
28 TOOLROOM. 28tn ST.
29 CENTRAL TOOL ROOM
30 CO^2 & ARGON GAS
31 PAINT EQUIP OVERHAUL
33 ELECTRONIC CLEANING
41 NASSCO STORE
42 YARD CONFERENCE ROOM
43 WAREHOUSE
44 WAREHOUSE
45 WAREHOUSING DEPT.
46 FIBERGLASS
51 ENGINEERING
54 QUALITY ASSURANCE
55 PATTERN SHOP
56 SECURITY DEPT.
58 CONTROL TOWER
59 TEMPLATE STORAGE
60 TEMPLATE STORAGE
61 LOCKER & SHOWER ROOM
62 WELDING SCHOOL
66 PRODUCTION OFFICES
68 COMPUTER SERVICES
71 CM-70 CONTROL WAREHOUSE
72 FED-MART WAREHOUSE
73 BOILER WAREHOUSE
77 STEEL YARD CONTROL
78 TRANSPORTATION OFFICE
79 N/C CARPENTER SHOP
80 GATE 14 SECURITY
81 GATE 6 SECURITY

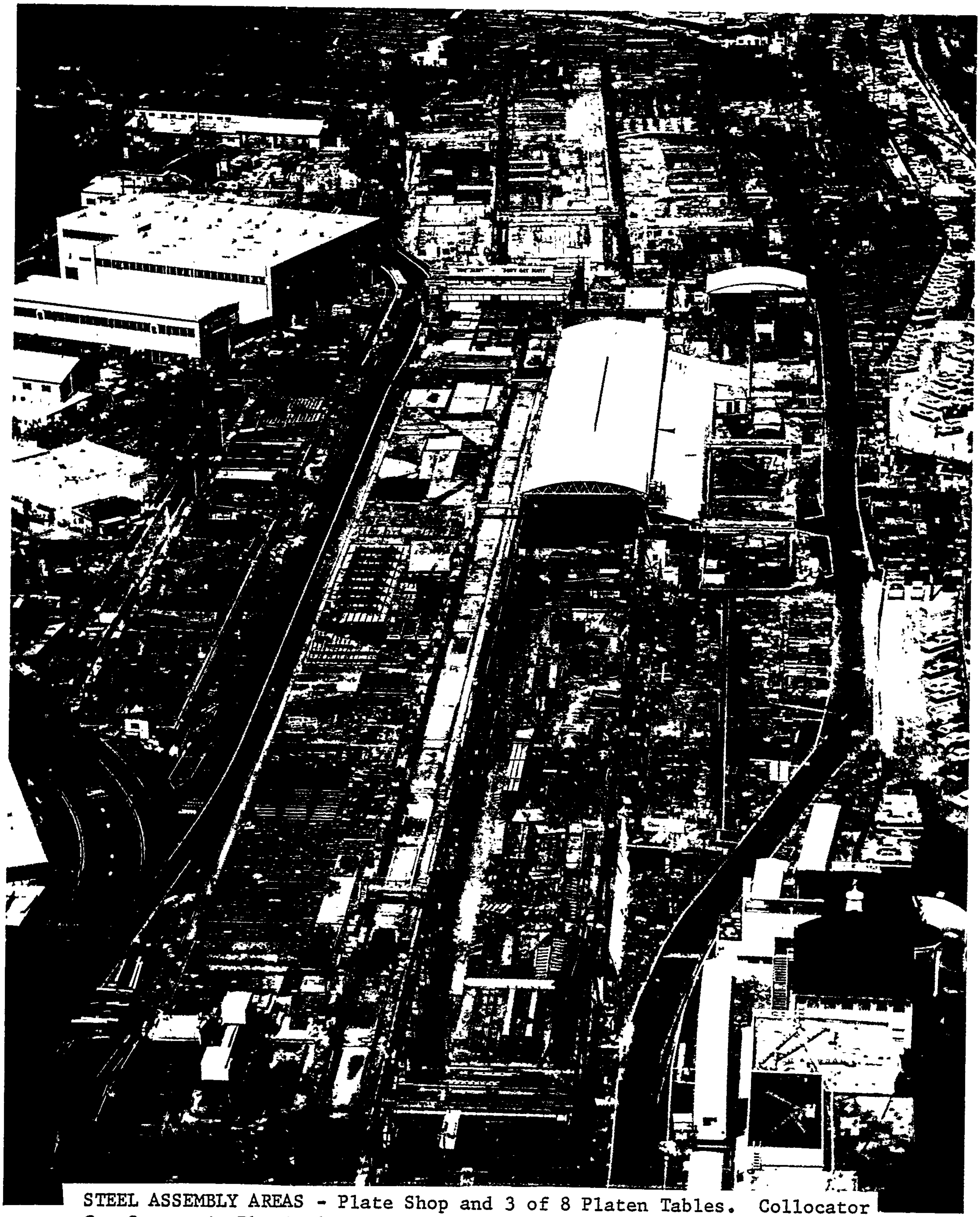
Figure 1



BUILDING POSITIONS

	DIMENSIONS		MAX SHIP SIZE		
	L	W	LOA	BEAM	DWT
No. 1 Building Dock	1000	176	980	170	200,000
No. 2 Inclined Ways	675	96	690	90	40,000
No. 3 Inclined Ways	906	115	900	106	90,000
No. 4 Inclined Ways	905	115	900	106	90,000

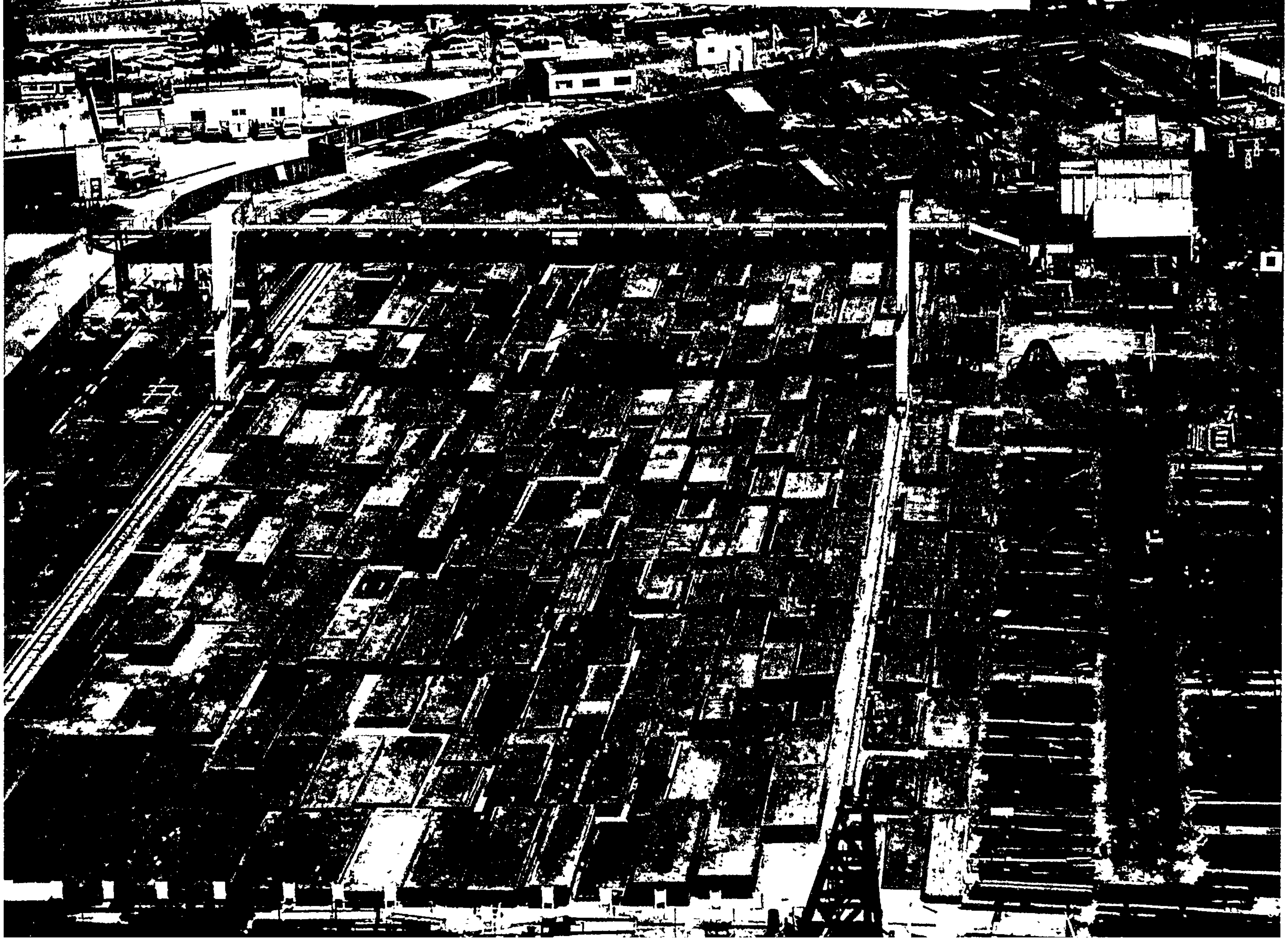
Figure 2 AUTOMATED STEEL HANDLING SYSTEM - Sketch of System as Installed in Existing Plate Shop, Platen Facilities.



STEEL ASSEMBLY AREAS - Plate Shop and 3 of 8 Platen Tables. Collocator Car System is Physical Divider Between Shop and Tables.

Figure 3

STEEL PLATE STORAGE AREA - "507" Crane Loading "T-1" Transfer Car to Feed Wheelabrator.



F1

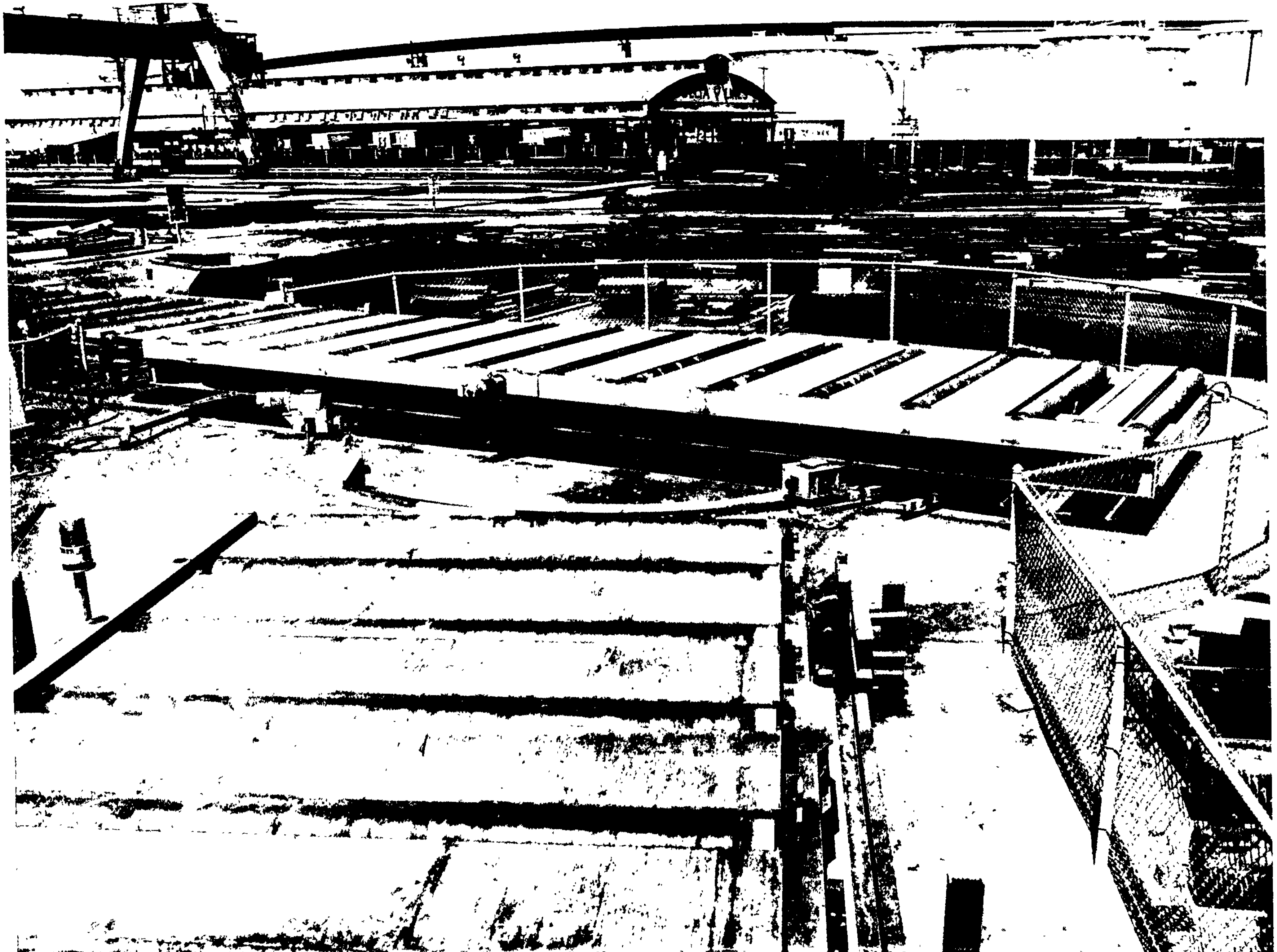


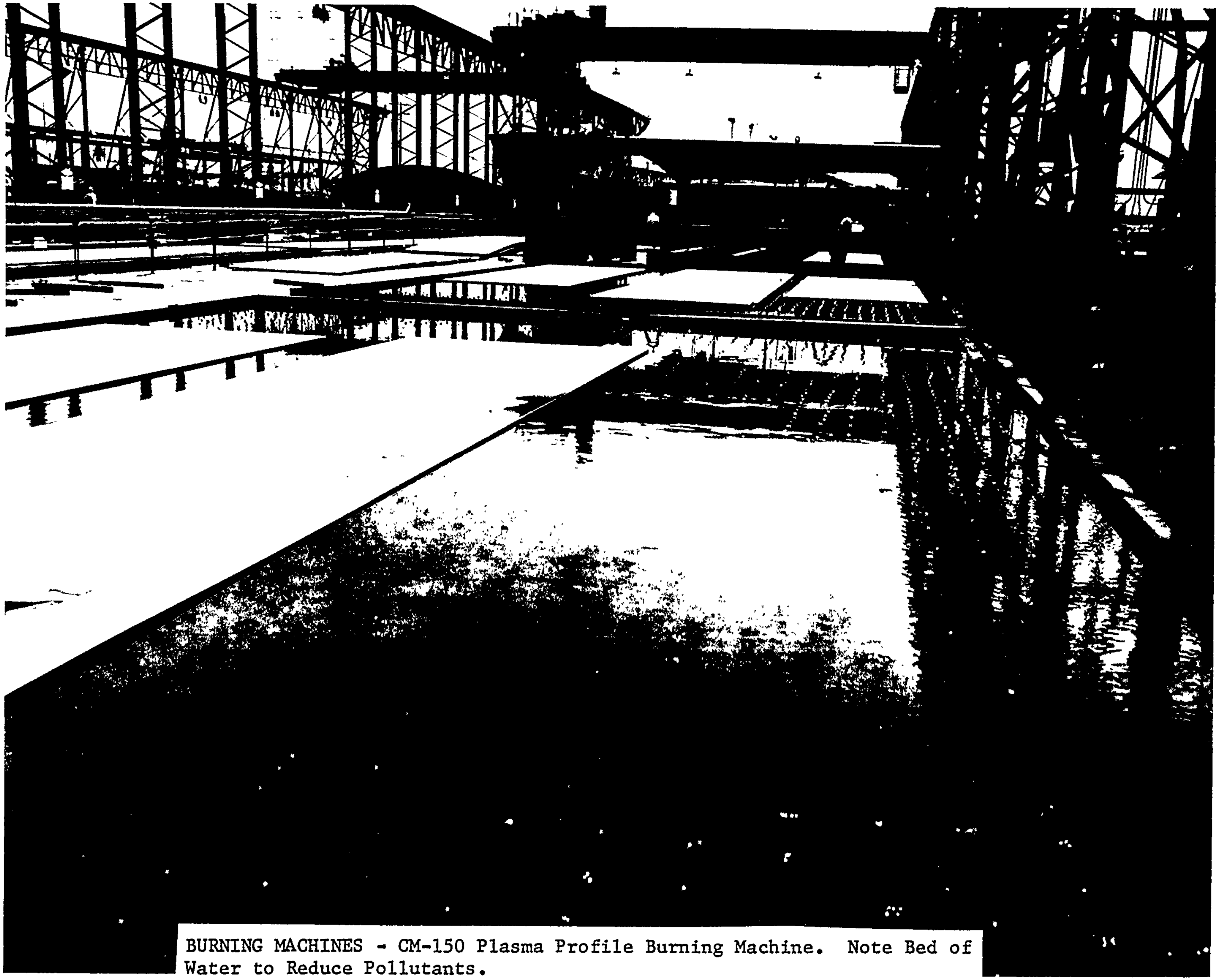
Figure 5

ROTATING TRANSFER CAR - DR1 Between Wheelabrator and Lower Collocator Run.

COLLOCATOR RUN, LOWER - Storage Area and CM-150 and CM-100 to Right of Tracks.

Figure 6

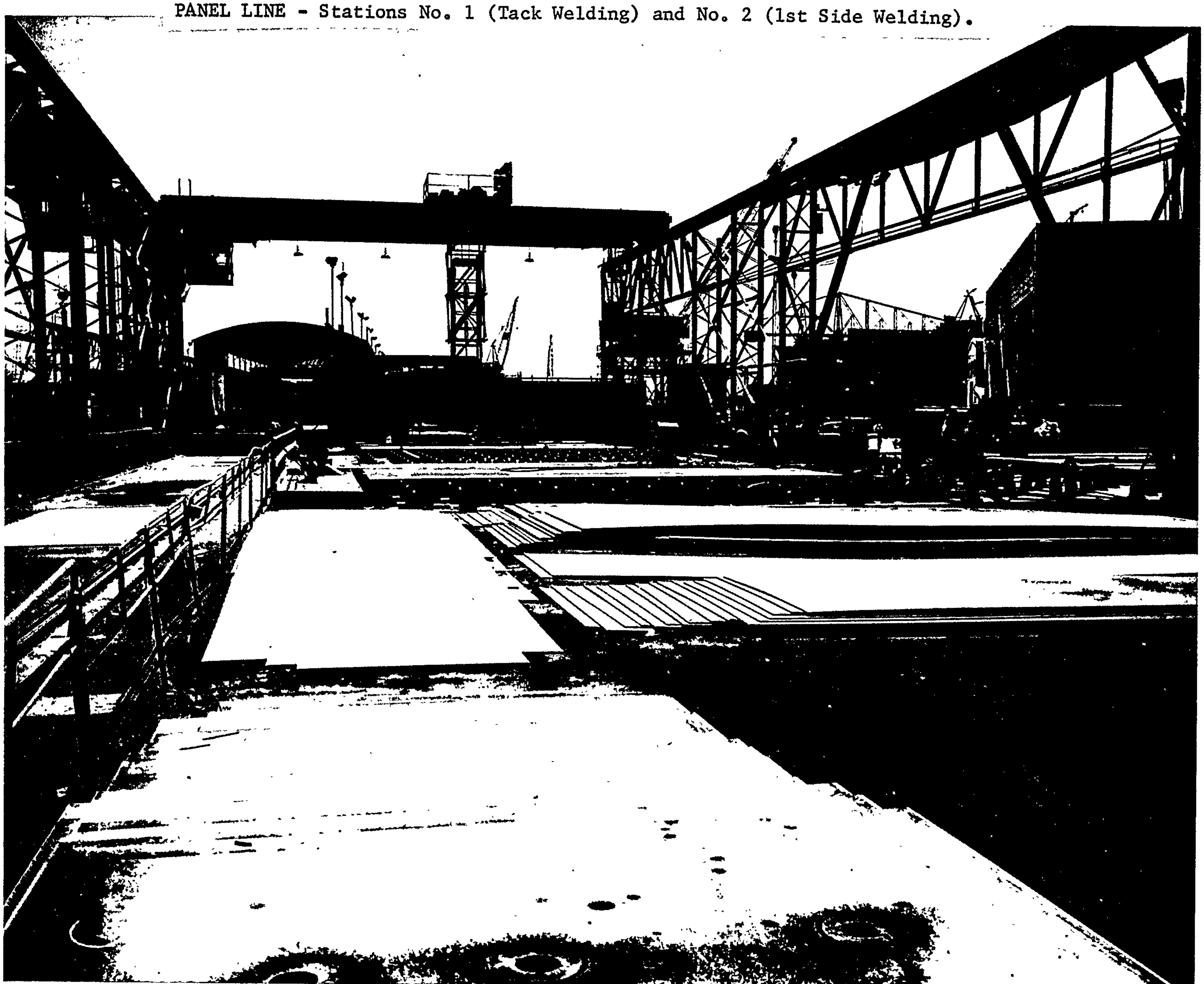
Figure 7

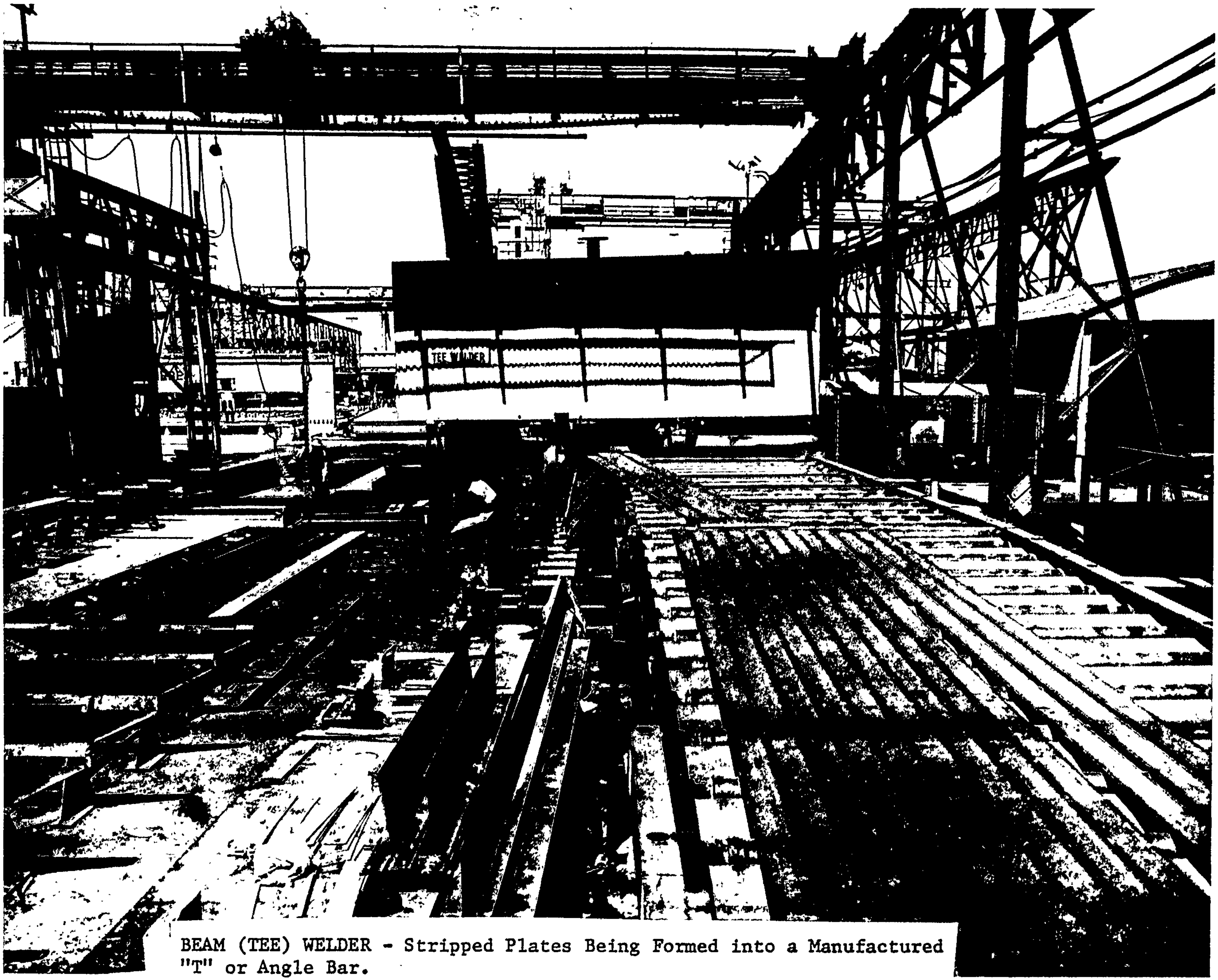


BURNING MACHINES - CM-150 Plasma Profile Burning Machine. Note Bed of Water to Reduce Pollutants.

Figure 8

PANEL LINE - Stations No. 1 (Tack Welding) and No. 2 (1st Side Welding).





BEAM (TEE) WELDER - Stripped Plates Being Formed into a Manufactured "T" or Angle Bar.

Figure 9

TRANSFER CAR - "T-2" Used to Transfer Plates from Lower to Upper Collocator Run, and to Load/Unload Burning Machines.

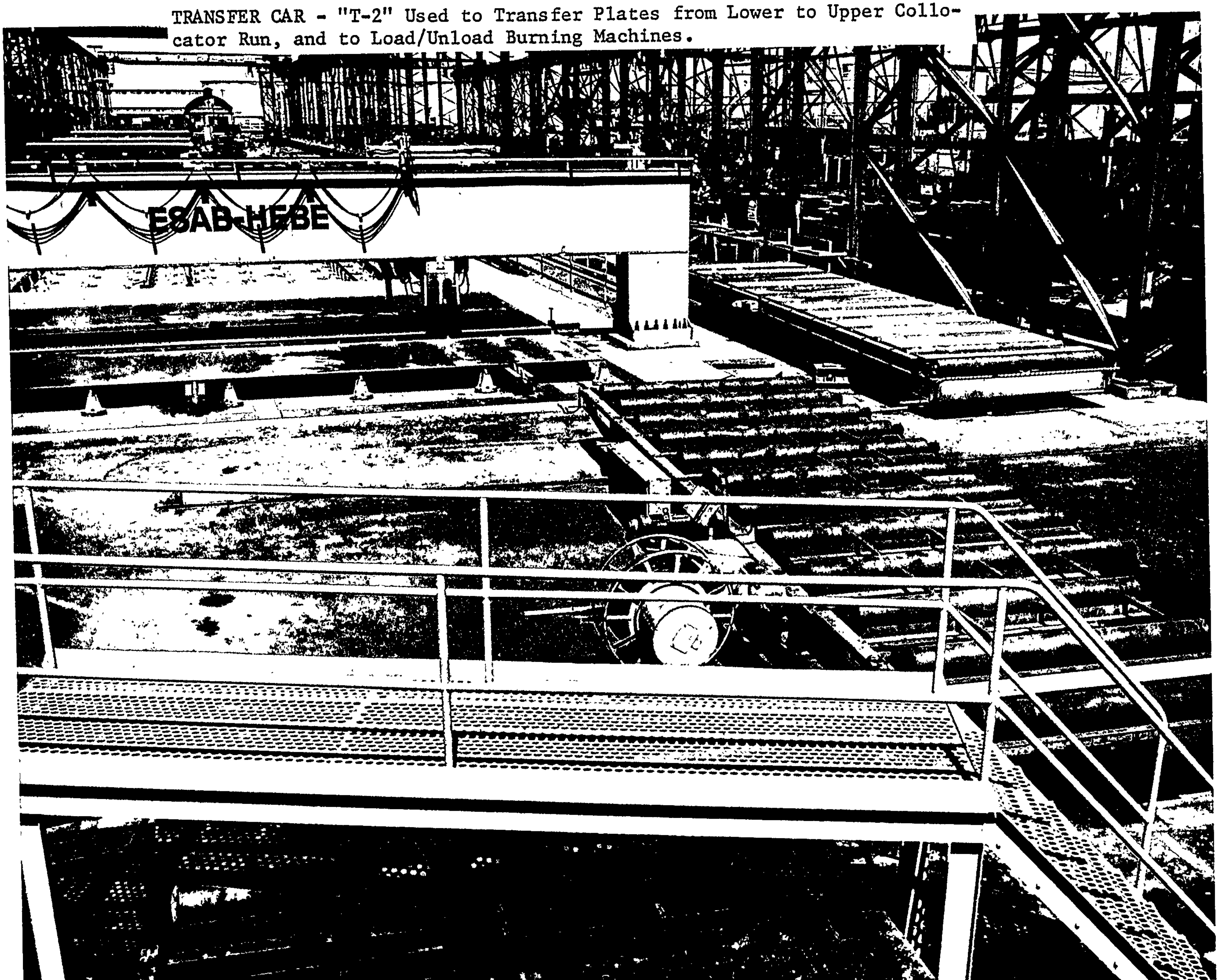


Figure 1

COLLOCATOR RUN, UPPER - Collocator Car and Adjoining Platen Table; Magnetic Beam Crane in Far Background.

Figure 11

CENTRAL CONTROL CONSOLE - Located in Control Tower, Used to Order Steel Plate Movements and Show Graphic Display of Activity in Process.

Figure 12

Figure 13

MAGNETIC BEAM CRANE - Used to Service Prefabrication Operation and Storage Area.

STORAGE RACKS - Work-in-Process Material Storage Racks and "Carrier" Load Storage of Tee Beams and Angles.

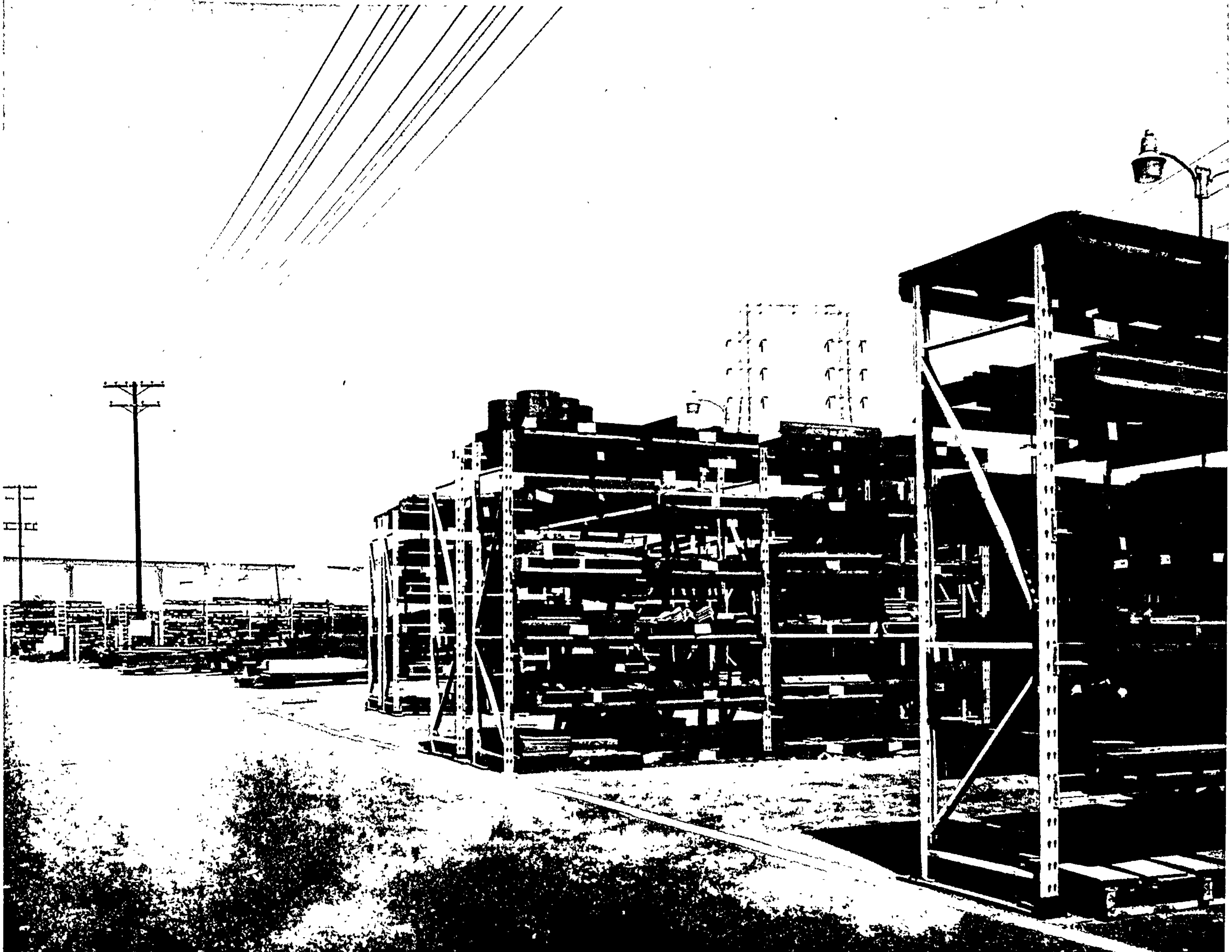
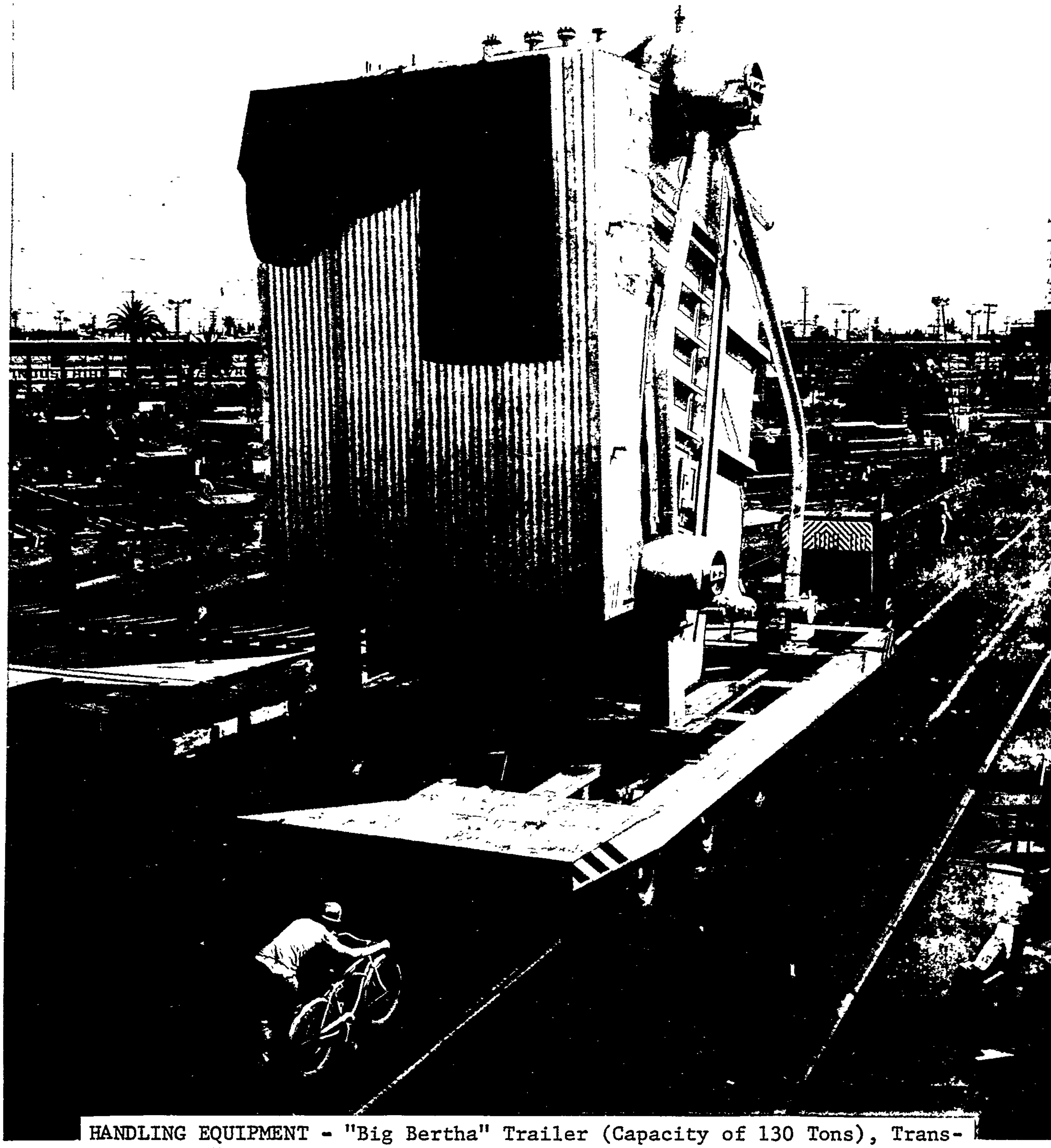


Figure 14

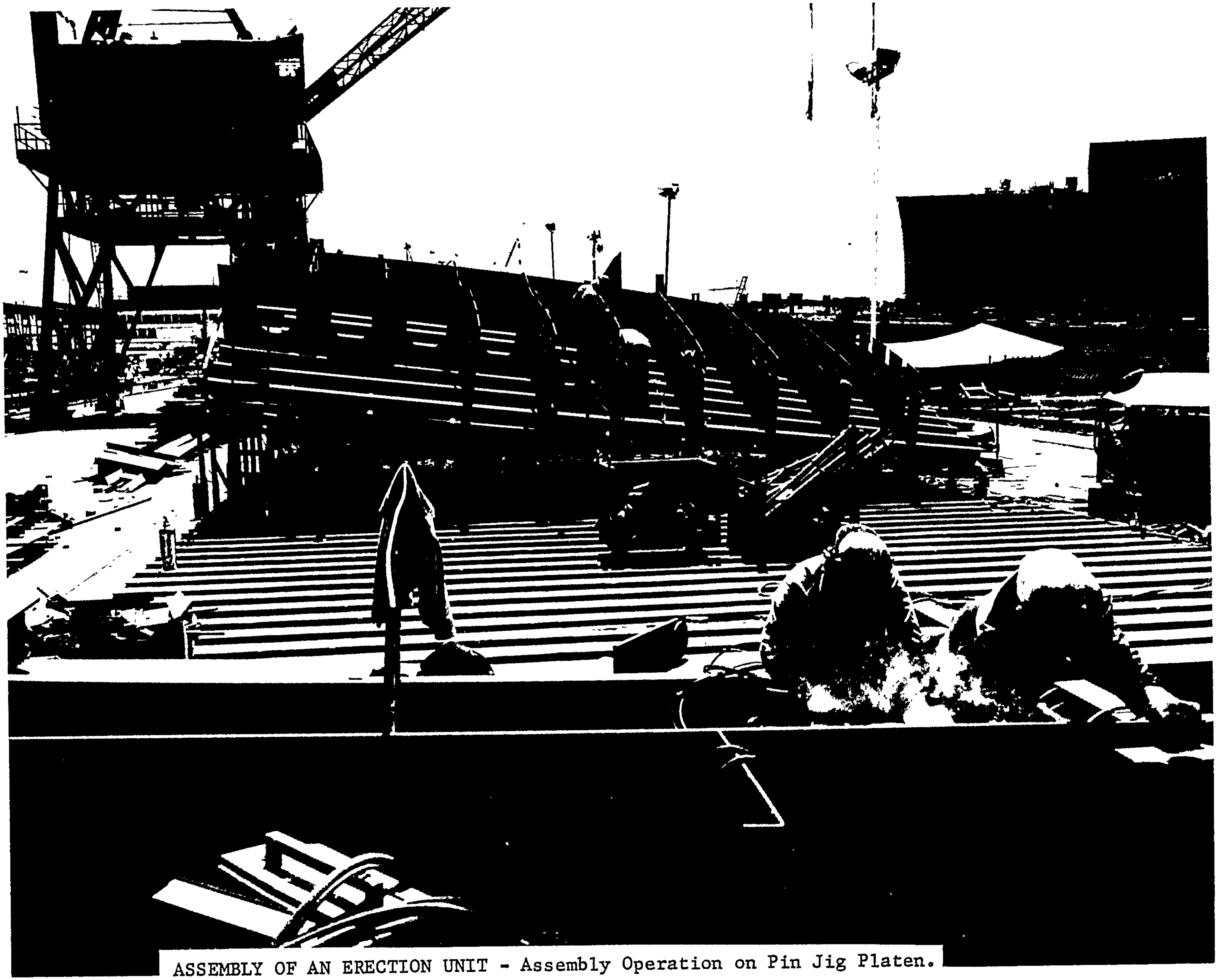
HANDLING EQUIPMENT - "Carriers" Used to Transport Bundles of Beams, Angles or Other Long Shapes.

Figure 15



HANDLING EQUIPMENT - "Big Bertha" Trailer (Capacity of 130 Tons), Transporting a "San Diego" Class Boiler Assembled at NASSCO.

Figure 16



ASSEMBLY OF AN ERECTION UNIT - Assembly Operation on Pin Jig Platen.

Figure 17

STORAGE OF ERECTION UNITS - Temporary Work-in-Process Storage of Painted Erection Units (Tank Tops, Innerbottoms).

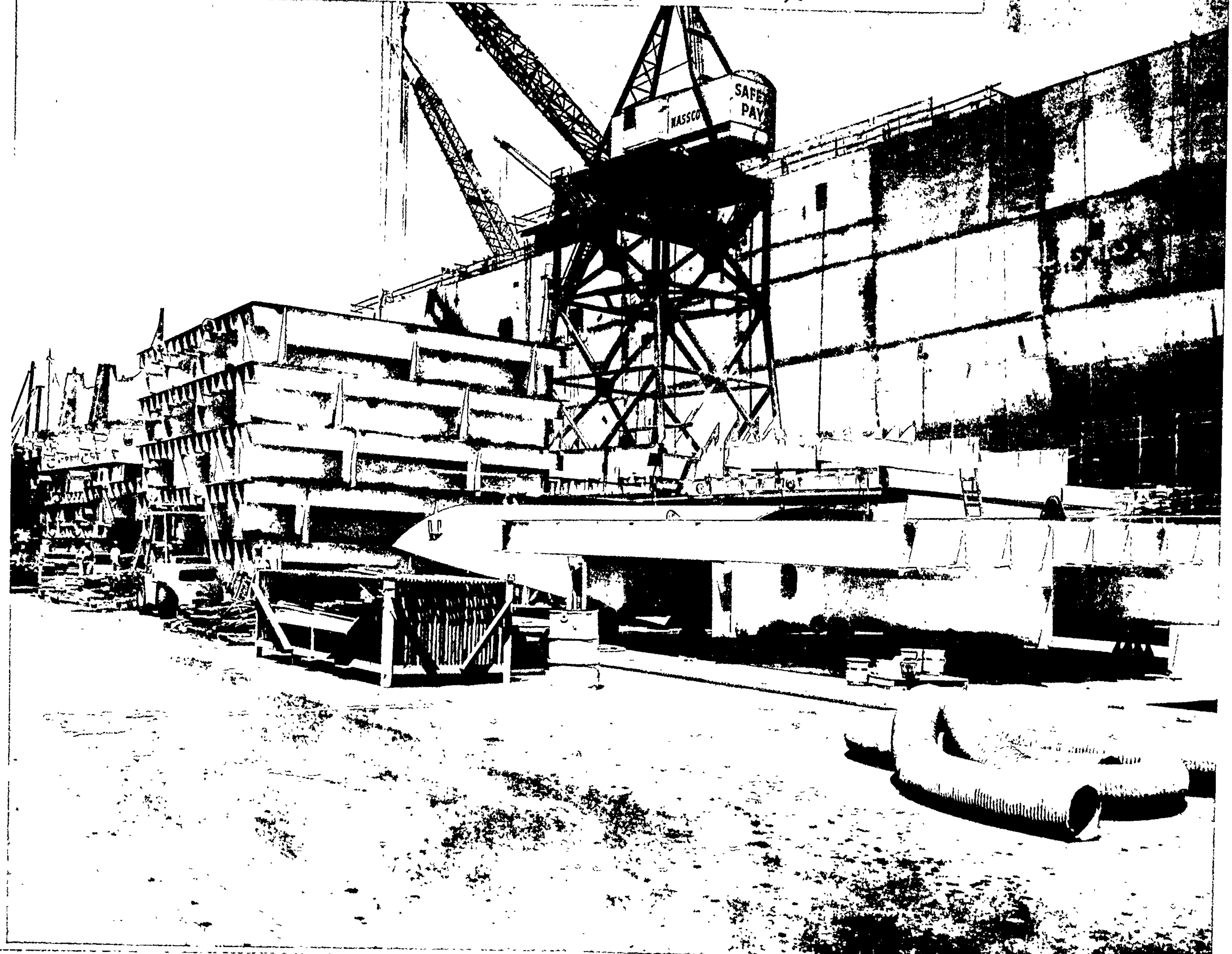
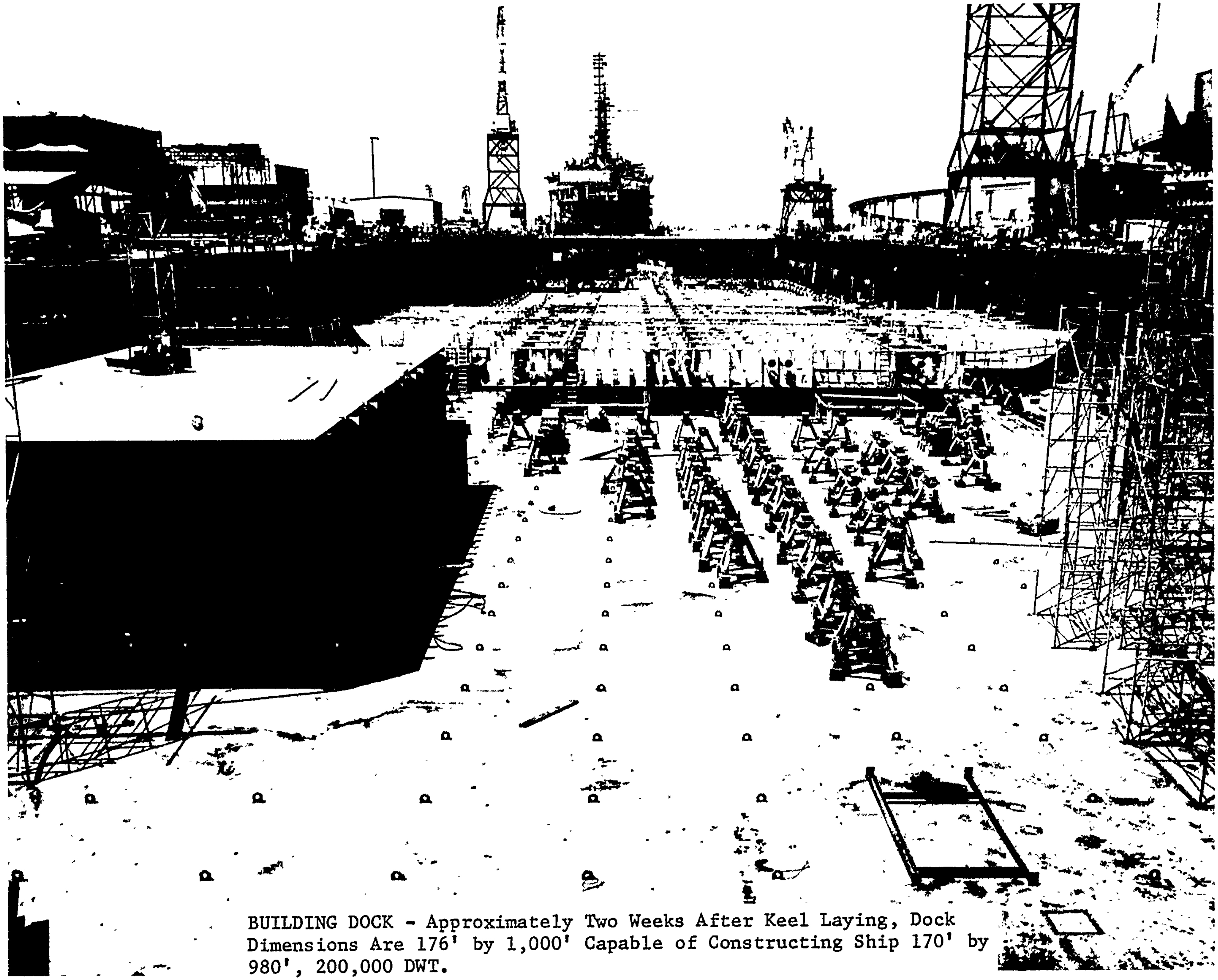
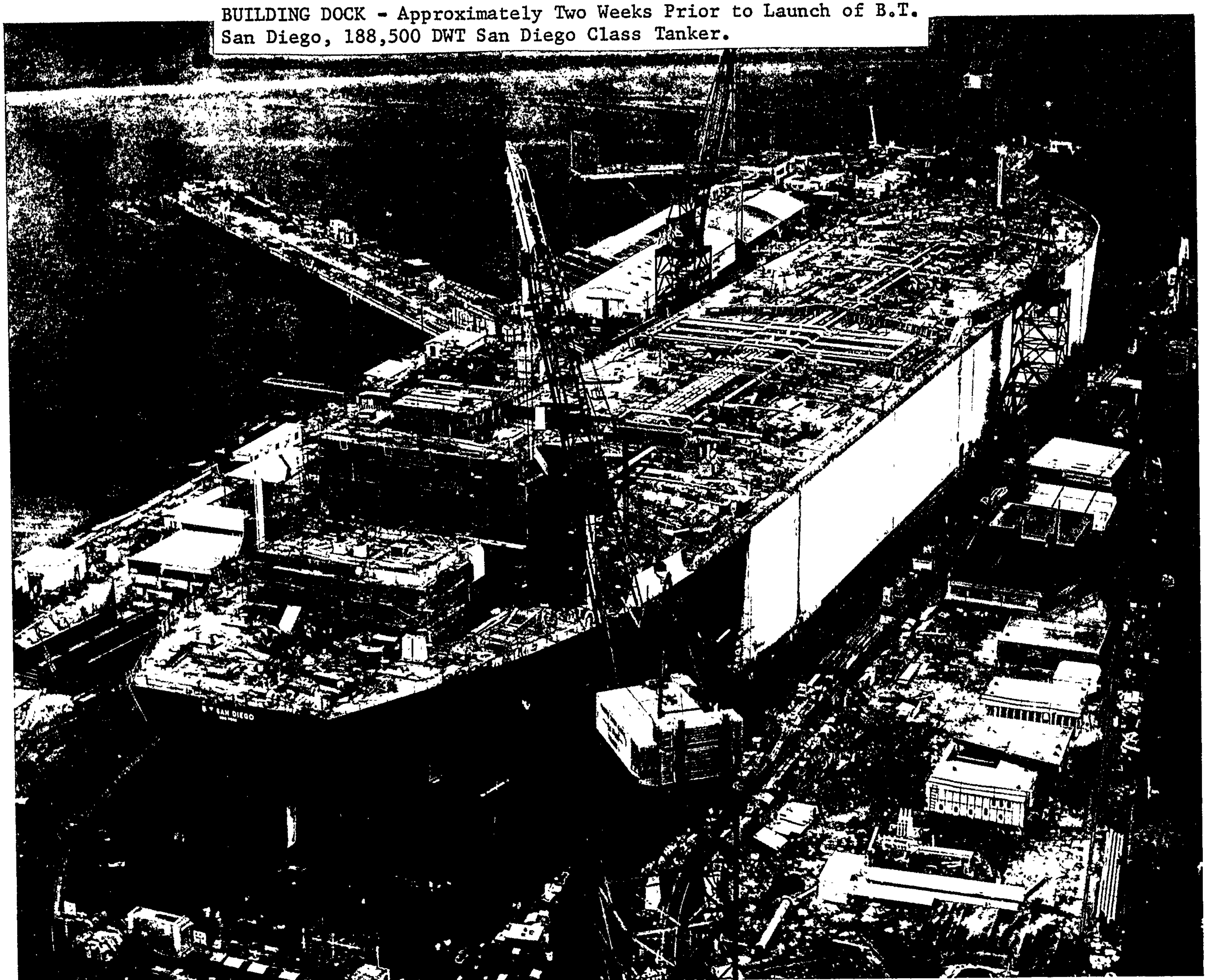


Figure 18



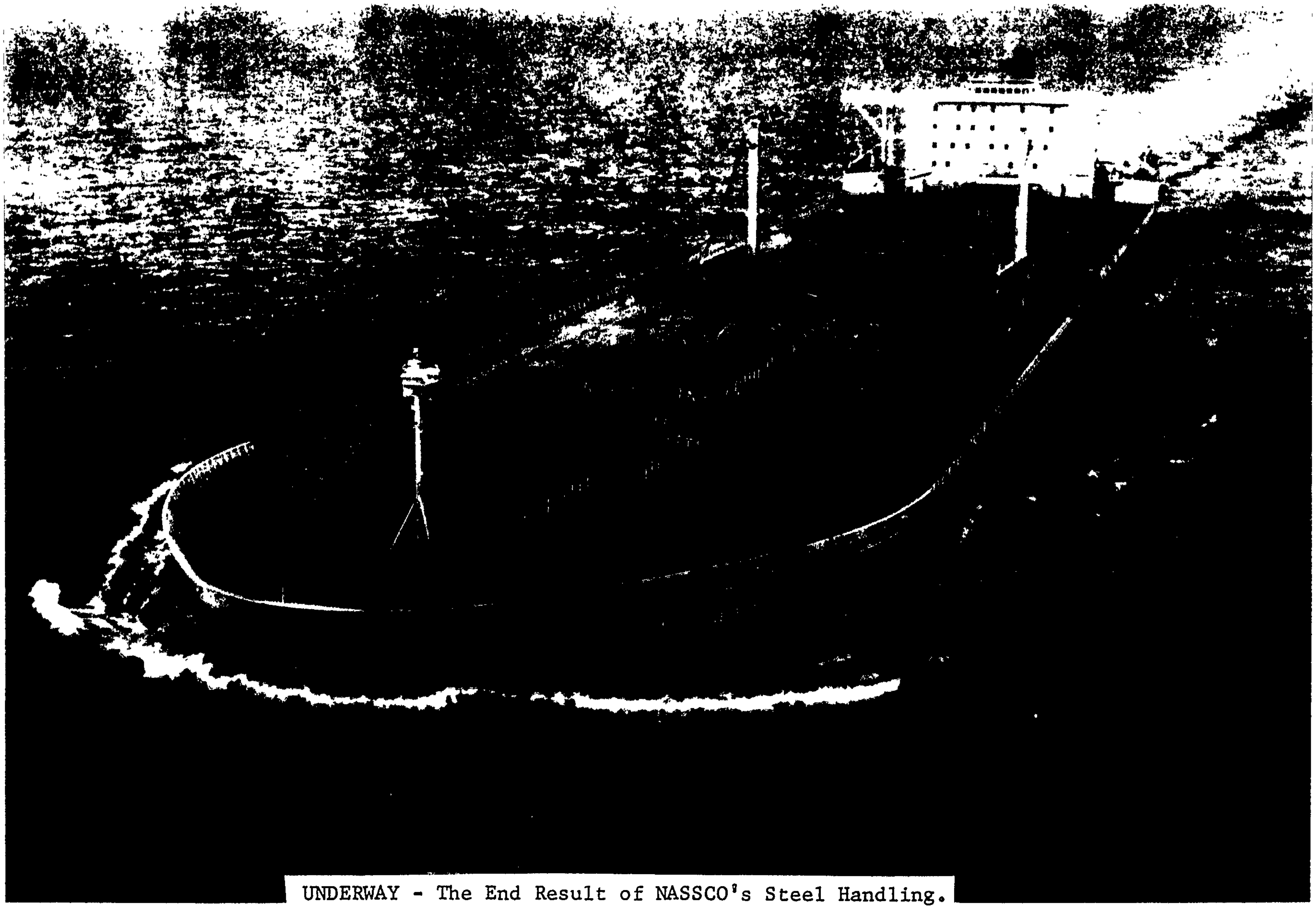
BUILDING DOCK - Approximately Two Weeks After Keel Laying, Dock Dimensions Are 176' by 1,000' Capable of Constructing Ship 170' by 980', 200,000 DWT.

Figure 19



BUILDING DOCK - Approximately Two Weeks Prior to Launch of B.T. San Diego, 188,500 DWT San Diego Class Tanker.

Figure 20



UNDERWAY - The End Result of NASSCO's Steel Handling.

Figure 21

0005

IMPROVING LABOR PRODUCTIVITY IN SMALL SHIPYARDS WITH COMPUTER ASSISTED STRUCTURAL DETAILING

M. R. Ward
RTL Incorporated
Gardena, California

Mr. Ward is the president of RTL, and is currently in charge of all the engineering work for the firm of consulting engineers. He has an S.B. degree in naval architecture and marine engineering from MIT, and an M.S. degree in civil engineering, and a civil engineering professional degree from California State University, Long Beach.

IMPROVING LABOR PRODUCTIVITY IN SMALL SHIPYARDS WITH COMPUTER ASSISTED STRUCTURAL DETAILING

Introduction

This is a story of using small resources to solve big problems. It describes a system now in use involving an application of small computers in improving steelwork productivity in small shipyards. A notable feature of the system is that it requires almost no capital investment. The costs of the system are charged to the job and the learning time for using the system has proven to be very short. Labor savings are quite dramatic. Manhours per steelwork ton have been reduced as much as 50% in some cases. The major emphasis of the system is directed toward the improvement of the most important labor components of steelwork, fitting, welding and erection, rather than the steelwork areas normally cited as candidates for productivity improvement, layout and cutting. The system requires a few people with some skill in layout and planning but less shipbuilding knowledge on the part of the majority of the production labor force.

Hand labor is the most important component of shipbuilding and it is difficult to improve productivity by capital investment

Shipbuilding is a labor intensive business. For example, the cost of steel is only about 25% of the total cost of a ship hull. In addition to being the major cost, labor cost is more controllable by the builder than is almost any other cost. This is especially true for those shipyards who are not responsible for the design of the hulls they produce.

If labor costs are the major costs of shipbuilding and if they are more controllable by the builder than other costs, it follows that the greatest productivity improvements can be achieved by trying to reduce the amount of production labor.

There are two major types of work in a shipyard, steelwork and outfitting. Whether steelwork or outfitting has the most labor depends on the ship being built. Tankers, workboats, and barges have a higher steelwork labor content while Navy combatant ships have a much higher outfitting labor content.

In the steelwork area, the majority of manhours are in fitting, welding, and erection. Layout and cutting operations are only 10-15% of total steelwork manhours. In outfitting the most labor is in installation of outfitting items. Shop fabrication of outfitting items varies and is sometimes subcontracted but is invariably less labor intensive than installation.

Both major labor areas, steelwork, fitting, welding, erection and outfitting installation, are hand tasks and not very susceptible to automation or mechanization. Heavy capital investment in facilities is not likely to improve these major labor areas very much. This is borne out by Japanese experience. Some of the 70 year old Japanese yards are as productive as their brand new yards. The Japanese built their new yards to increase output or build larger hulls than could physically be produced in the older yards, not primarily to increase labor efficiency.

The major emphasis in this presentation will be on steelwork labor improvement since this is most important to builders of steel workboats.

Hand labor is more efficient if the worker understands his tasks clearly and his work is properly organized

If capital investment will not improve steelwork labor productivity, what will? The answer is twofold: (a) to improve the worker's understanding of his tasks by giving him clear work instructions and providing him with simple tools and, most importantly, all the material he needs to complete the work expected of him; and (b) scheduling the work so it is done earlier in the production process when access is better and work can be done most efficiently.

To illustrate the requirements for efficient fitting, welding, and erection let us consider the task of building a side shell panel for a steel hull. The following things are needed by the worker to do his job quickly and economically:

a) A picture of the completed panel showing what is installed on it and where it goes plus a list of what goes loose with the panel to the next assembly operation.

b) A list plus visual description of <u>all</u> the pieces he needs to make the panel plus where they come from in case they are missing.

c) Weld symbols, touch up paint, lifting lugs, scaffold clips, outfitting items to be installed, tasks to be done by other trades, etc.

d) Accurate dimensional information enabling work to be layed out, cut and assembled with minimum use of cut to fit procedures.

Shipyards often use Naval Architect's approval drawings for building. These drawings show the general construction but are poorly suited for direct use in the shipyard. The drawings are deficient in the following respects:

a) They are too big and show a little bit of information on a lot of hull. For example the Structural Profile shows a lot of structure all over the ship but not nearly enough to build a single panel.

b) Several large drawings are required to make one panel and a lot of study is required by the worker to figure out what he is supposed to do on his one panel.

c) Very little if any accurate layout information is included on any of the drawings.

d) There is no definition of what constitutes a completed panel or unit of work.

Under normal conditions a tremendous amount of production labor is spent on interpreting drawings just to figure out what to do. This is wasted time. The manager wants to see sparks and arcs, not people studying plans and looking for material.

The conclusion that must be drawn is that steelwork labor efficiency can be improved by giving the worker decent drawings and work instructions tailored to his tasks.

<u>Production drawings prepared with computer assistance are necessary to achieve low steelwork manhours</u>

Several small steel hulls have been built using special steelwork production drawings made with the aid of a minicomputer. This has been a small resource effort to solve a big problem. The computer does not make the drawings. It only provides lots of accurate dimensional information for use in making the drawings. To date the drawings are 100% hand made since we have been unable to justify a plotter for our computer.

The drawings themselves are made strictly for production purposes. A typical drawing will show an individual panel to be fabricated plus complete dimensional information and accurate bill of material. The mechanic needs only the one drawing to build the panel. The same drawing is used by the layout man to prepare the parts for use in building the panel. Using drawings of this nature, steel hulls have been built from prefabricated panels with less than 5% of seams trimmed at erection and then only an occasional sliver needs to be removed.

Using the production drawings the construction procedure is different from the normal small boat production procedure of laying the keel, erecting and guying off frames and bulkheads, installing longitudinals, and erecting, trimming, and fitting raw plate to the skeleton. The procedure with the production drawings is to fabricate and weld the panels on the ground, erect the keel and bulkheads, and erect the panels on the hull. Using the revised procedure about half the work normally done in the air is done on the ground where it is much easier to do and the remaining work done on the ship is reduced because trimming to fit is substantially eliminated. An additional benefit is that product quality is improved since weld gaps are just right and fitting panels rather than frames and plates gives a smoother hull. Less extra stiffening and trimming to fair up frames is necessary also.

Returned cost figures indicate that labor manhours, excluding the manhours spent in making the drawings, have been reduced by as much as 50% over conventional small boat building practice.

The type of production drawing used to achieve these savings requires accurate dimensional information from computer lofting and shell development to make the system work. Our concept is to use the computer as a tool to improve the essential hand labor tasks involved in steelwork. The production worker need not know anything about computers. He may not even see a computer printout or can be unaware that computers are helping him.

The drawings and work instructions he uses are tailored to the worker's needs, not to the requirements of the computer. The computer is subservient to the worker, not the worker to the computer system. This is very logical since there are a lot more workers than computers and computers operate at 60 HZ all the time while worker's output depends on how easy the work is, how they feel, etc.

Low steelwork manhours require labor specialization, repetitive tasks, and efficient positioning of the work. These are achieved with steelwork production drawings

Efficient utilization of labor involves a number of work organization features as follows:

a) Work tasks must be simply and clearly defined and done in a uniform way from job to job to reduce mistakes, slack time, and relearning.

b) Identical types of work must be lumped together so that batches of similar tasks are done at one time. For example, the ideal method of cutting parts is to light the burning torch once, and cut all the parts for an assembly before turning it off. This provides work task specialization, one of the most powerful ways of increasing productivity.

c) Work must be positioned properly for ease in doing the work. Consider fitting plating to frames. Fitting loose frames to plating on the ground in flat position under cover is more than three times as efficient as fitting plates to frames erected on the ship, especially if the plates and frames are cut properly in the first place.

d) Elimination of cut and try fitting operations saves both fitup labor and welding labor. Cutting plating to fit on the ship is very awkward. It requires a lot of out-of-position work plus extra equipment and scaffolding and the result is often pretty sloppy and requires extra welding time to fill up the gap. In contrast, fitting a properly cut seam together on the ship is quite simple if started in the right place and the weld seam quality is very good.

e) Erecting complete panels on the ship is cheaper than erecting frames, guying them off, aligning them and pulling raw plate to the frames since fewer pieces need to be erected and less supports used to keep everything in alignment.

From the above list it can be seen that there are substantial production economies to be obtained by changing the production process to take advantage of steelwork production drawings. The change in the production process is not a drastic one. The individual work tasks of layout, cutting, fitting, welding, and erection are still done the same way as always. They are only simplified and consolidated into repetitive batches to make it easier and more enjoyable for the worker.

The prefabricated panels are only 10% to 20% heavier as a rule than an untrimmed plate so required crane capacity is little different than before.

Are 50% steelwork labor savings unrealistic? Surely yes for a fairly efficient yard already building panels but not for a yard using conventional cut and try methods and doing most of the work on the ship.

Some justifications for the 50% level of potential savings are:

a) Fitting and welding stiffeners to plates on the ground requires one third the manhours of doing the same thing in the air on the ship.

b) Fitting and welding plate seams which need not be trimmed is less than half the cost of trimming, fitting and welding raw plate.

c) Batch processing in layout, cutting and panel assembly is less than half the labor cost of cut and try methods.

d) Standby time and study time by workmen is cut about in half.

e) Accurate Bills of Material eliminate lost time hunting for material.

f) When the draftsman makes the drawings, he simulates the layout and assembly process that the production worker uses. In doing so he uncovers problem areas and makes "mistakes" on paper which he can correct as he goes along. It is far cheaper to make mistakes on paper and correct them than on steel. While not infallible, the detailing process does result in fewer errors and less rework than "leaving it up to the boys on the ship."

Each of the above savings is substantial, many more than half of conventional labor requirements. From this cursory analysis labor savings of 50% over conventional small yard fabrication methods are not unreasonable. At any rate the labor savings will far outweigh the cost of preparing steelwork production drawings.

Typical Steelwork Production Drawings contain a wealth of information for the worker and promote efficient planning

Steelwork Production Drawings are product oriented not systems oriented, local in scope not global, and complete in their local area. They contain the following:

a) A picture of the work to be done giving all necessary layout information either in tabular form or by dimensions on the part.

b) Accurate Bill of Material enabling raw material to be consolidated before fabrication is started.

c) Source and destination references for material

d) Forming instructions for parts requiring forming.

Some special features of the format are worth mentioning:

a) Each drawing covers a clearly defined series of tasks and is generally independent of other drawings.

b) Each drawing is essentially preplanned so that production planning instructions over and above those incorporated on the drawing are minimal. The planner need only say "do it by X date" to complete the work authorization.

c) Having layout dimensions on the drawings simplifies checking of work and improves the fabrication accuracy thereby lowering the cost.

d) Drawings are fairly small and easy to handle on the job. If there are problems, say a piece is missing, there is a clear picture of the piece somewhere on the drawing. A journeyman can send a helper to look for it rather than have to go himself.

Steelwork Production Drawings are probably more expensive to prepare than normal working drawings. It is usually not necessary to prepare both working drawings and steelwork production drawings. Starting from the approval drawings submitted to Coast Guard or ABS, the Steelwork Production Drawings can be prepared directly. Preparation costs depend on a lot of factors. A typical cost for 1/4" plate with 18" frame spacing for a high class workboat is about $150.00 per ton. For 1/2" plate this cost could be reduced about 40%.

A comment is in order on layout accuracy. Many authorities state that Numerical Control is required for super accuracy in cut parts. The reason for super accuracy is not Numerical Control; it comes

mainly from the computer. For example, if a shell plate were developed by hand, digitized, and cut by Numerical Control it would not fit too well because the errors in hand development are accurately incorporated into the cut plate according to the garbage in-garbage out principle. If a shell plate is computer developed, layed out by hand and cut by radiograph, the fitup will be excellent. The accuracy comes mainly from the computer, not from the N/C machine.

Steelwork Production Drawings are dependent on accurate dimensional information which can only be generated by computer. The computer need not be large to do the job. A minicomputer can develop shell accurately and also come up with accurate returned offsets. This is all that is needed to prepare accurate Steelwork drawings and achieve really substantial savings in fitting, welding, and erection labor.

No capital investment is required to achieve these savings; the costs of making the computer runs and drawings are charged to the job and are paid for by production labor savings.

Actual work experience with computer assisted Steelwork Production Drawings has been very profitable to builders using them.

Steelwork Production Drawings have led to notable production savings in small yards. Some examples follow:

A Central American shipyard built two 72 foot Shrimpers using Steelwork Production Drawings. They were the first steel hulls ever built in the yard. The yard manager, an American, said that he would have had to go out of business without the drawings. He is planning to use them on a pending order for ten anchovy boats.

A small builder used Steelwork Production Drawings on the forward half of an 80 foot hull. The after part was built conventionally. The construction manhours were half as great

for the forward part than they were for the after part. The shipyard personnel commented on how easy it was to install the prefabricated panels compared to erecting frames and pulling plate to the frames. They also stated they were able to do more and better work with far less effort.

A small repair yard is presently building their first steel hull, a 50 foot water taxi. Because of the detailing and planning contained on the Steelwork Production Drawings, they ordered domestic steel from the mill rather than from the warehouse and saved about 10% from the foreign steel price. They have worked an average of two men per day for 3 weeks straight time only and have completed almost half of the panels ready for erection including blasting and priming of the steel. This includes setting up a work area from scratch and training yard personnel with no previous steel hull building experience. This job is still underway and yard personnel are eager to work on the job. The work pace is very good because the work is clearly laid out on the drawings and there is always something ready for doing. Just pick up a drawing and go to work!

Every user of Steelwork Production Drawings is convinced of their utility in increasing labor productivity, improving quality of the work and making the work easier to manage. They are all going to use the system on their future jobs.

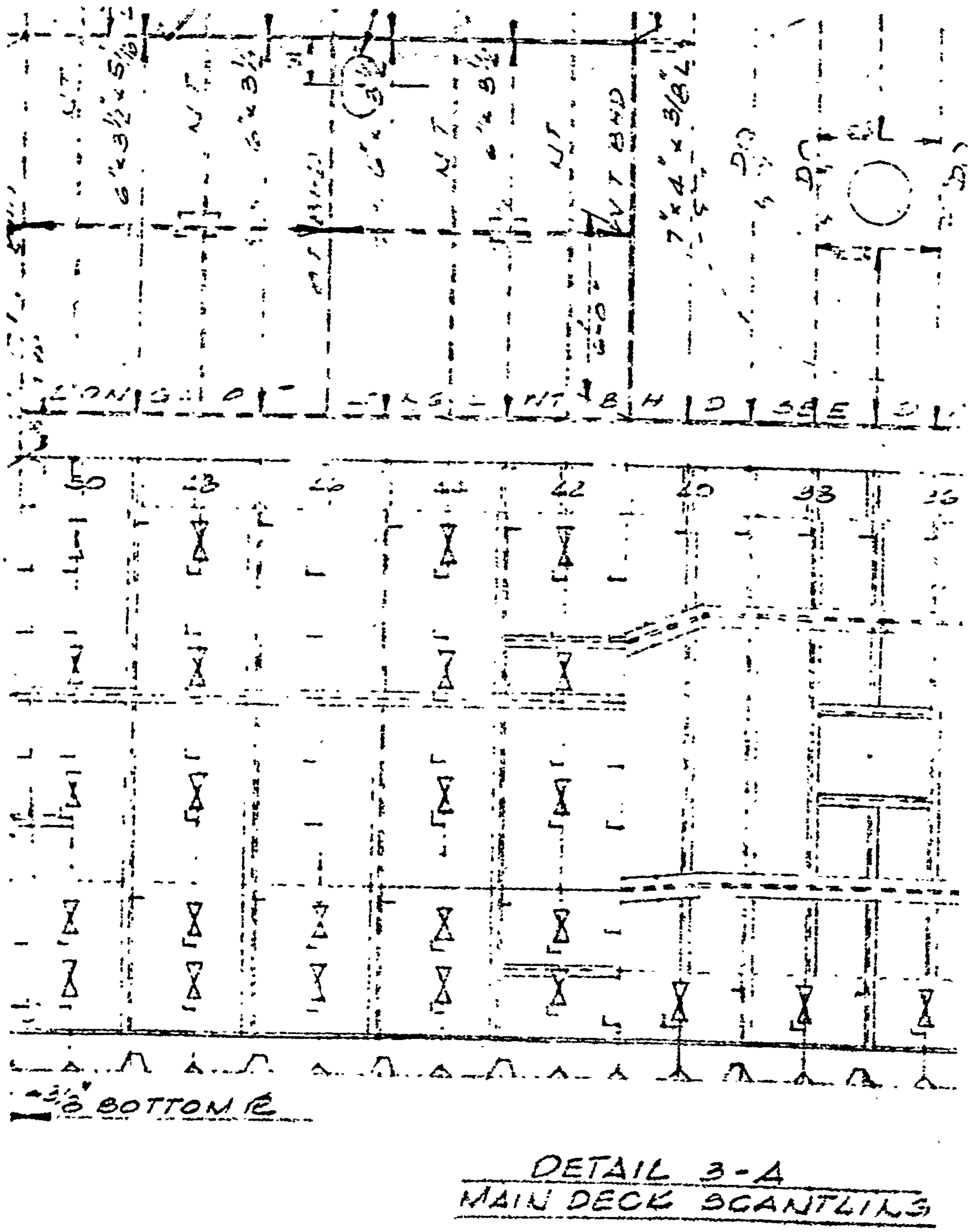
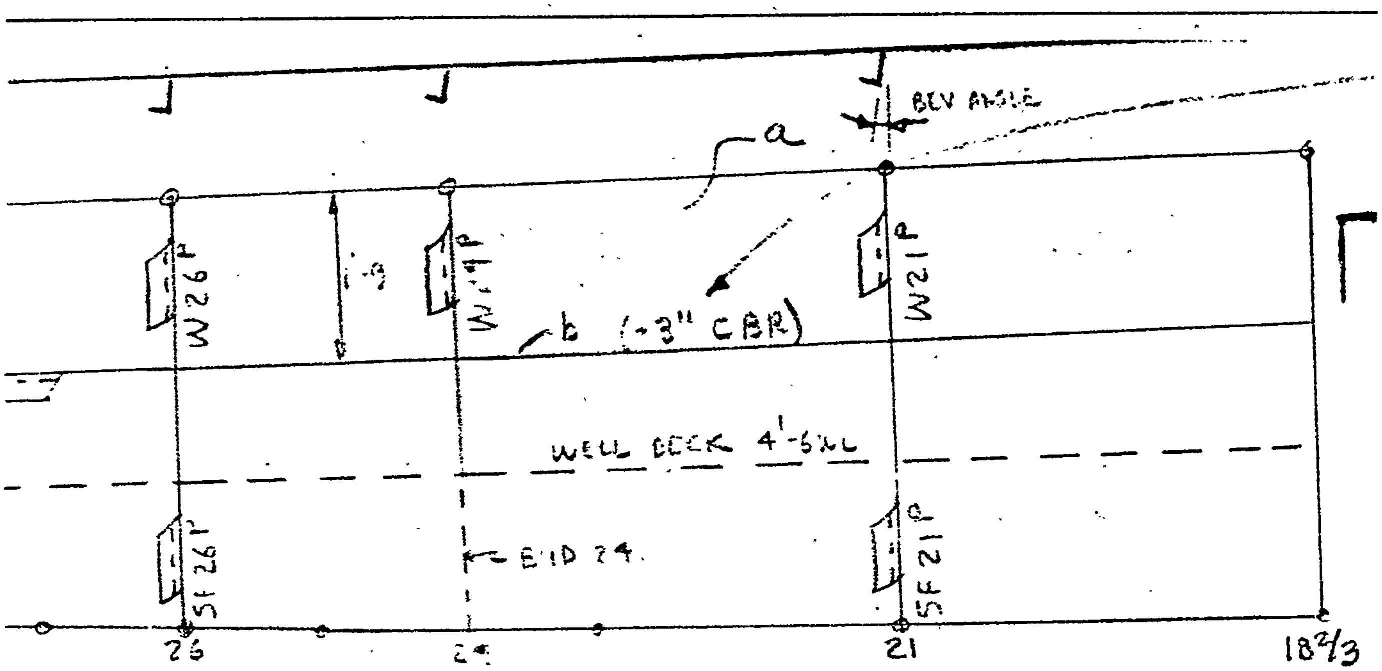


Figure 1 Typical Drawing From Naval Architect

This is a small part of a much larger drawing showing all decks on an Offshore Supply Vessel. Although the drawing covers over 20 panels, there is not enough information to fabricate a single complete portion of the ship. Even the panel boundaries are undefined. This drawing can be greatly simplified for submittal to regulatory bodies if Steelwork Production Drawings are prepared.



ONE SIDE SHELL ASS'Y SS-1P SHOWN (LEG C.B.)
ONE SIDE SHELL ASS'Y SS-1S OPP

LOWER TRACE		BOTTOM BEVEL	TOP BEVEL	FRAME GIRTH	BILL		
X	Y				QTY	PC MARK	DESCRIP
					1P/1S	SS-1	SIDE SHELL
1-8-1	0-3-3				2	a	60"x10.2
3-3-12	0-2-8				2	b	L 3x2½x
6-4-0	0-1-12	FR 2? 5°	5°		4	c	
12-9-3	0-1-3	FR ? 2°	2°		1P/1S	SF21	L6x3½
15-4-3	0-1-10	FR 24 1°	1°		1P/1S	SF26	
15-9-3	0-2-10	FR ? 6°	6°		1P/1S	SF28	
21-10-3	0-7-7				1P/1S	W21	

Figure 2 Typical Steelwork Production Drawing

In contrast to the Naval Architect's drawing, this drawing shows complete information to fabricate a Side Shell Panel ready for installation on the ship with no trim required.

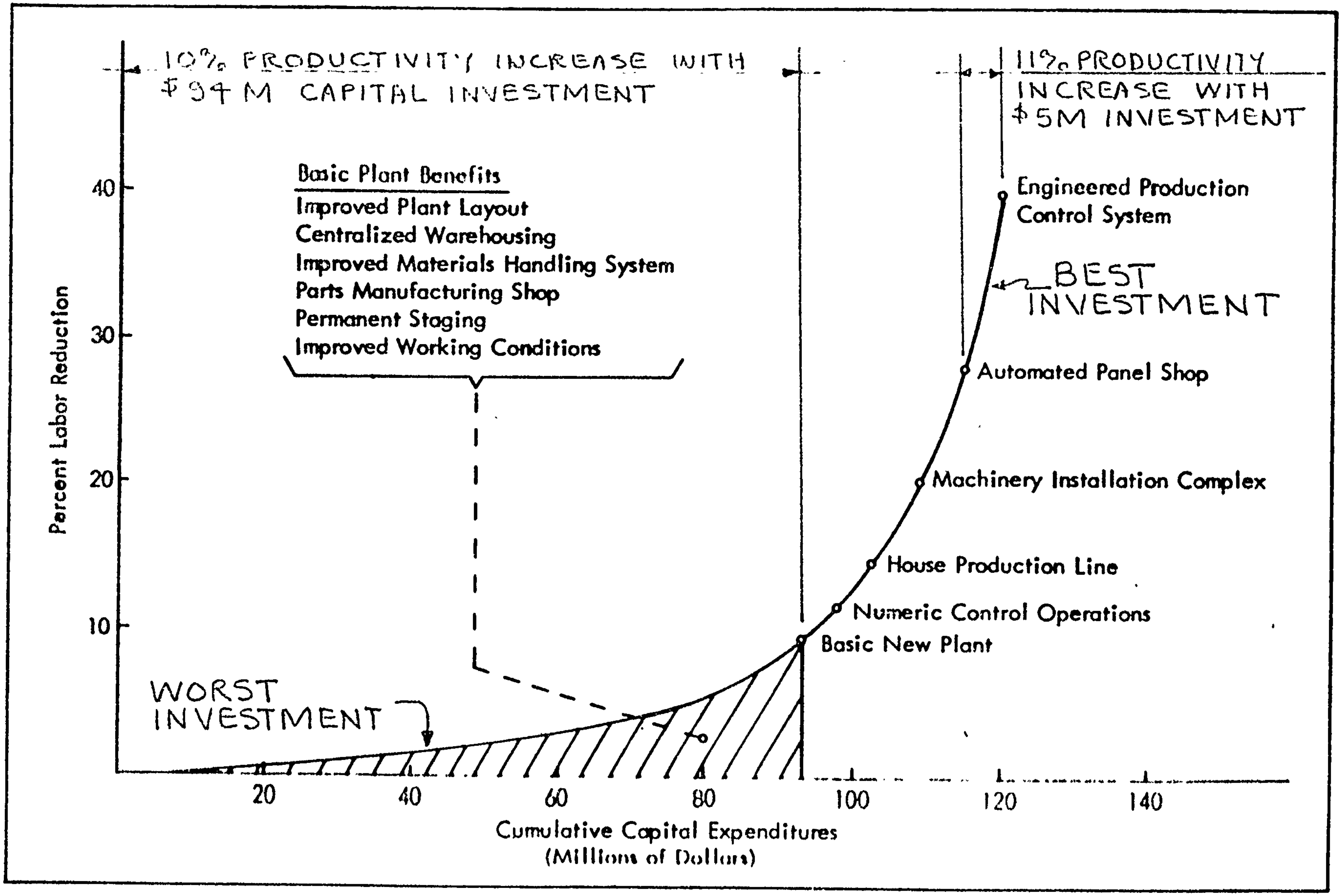


Figure 4-13 PRODUCTIVITY OF CAPITAL

Figure 3 is an excerpt from Maritime Administration CMX Project Report

AUTOKON ON A MINICOMPUTER

Dennis K. Medler
Designers and Planners Incorporated
Galveston, Texas

Mr. Medler has 4 years of experience in the aerospace industry as liaison engineer. He has 8 years of experience in shipbuilding (numerical control). During the past 5 years at Designers and Planners, Mr. Medler has been Director of CASD and responsible for the total computer effort including management of the AUTOKON 71 programs

Jack Harper
Designers and Planners Incorporated
Galveston, Texas

As Systems Analyst, Mr. Harper is responsible for the maintenance, upgrading, etc., of existing software and the implementation of new software at Designers and Planners. He has a B.D. degree in electrical engineering and a B.S. degree in mathematics from the University of Houston.

Part I:

On November 12, 1977, Designers & Planners, Galveston office, accepted delivery of a Prime 400, computer. In mid-December the first of the Autokon-. 71 programs was successfully converted to the Prime. The entire conversion was completed by the end of February.

To understand why this took place, we need to look at our previous system, its capabilities and limitations, as well as answer the following questions:

(a) What will satisfy our future needs?

(b) By changing, what did we gain?

A study of our computer system and its possible replacement was undertaken about two years ago. At that time our computer equipment, had the following capabilities:

(a) Two Hewlett-Pacard.2100's .

(1) One was a 24K word machine with two''l.2 megaword disks and drives. This was used primarily to emu-. late a Univac 1004 for communication with our host computer (Univac 1108). Accessing the 1108 and our resident Autokon-71 programs our manuscripts were processed and the output was directed to the line printer and the plot data to the disk file.

(2) The second 2100 was a 12K word machine, which served as a director for our Gerber 1275 drafting system. With a communication interface between the two 2100's the plot data could be drawn on the 1275 tables directly from disk.

(b) Three peripheral devices

(1) 200 lines per minute line printer.

(2) Paper tape reader/punch

(3) 600 CPM card reader

The limitations were:

(a) The HP21OO system was not a multiuser system, making it a very expensive terminal.

(b) Program enhancements to the Autokon systems were limited, due to time sharing cost.

(c) Our system was a batch system, meaning that, after the parts programmer had coded a part, it then had to be key-punched, verified, sent to the host computer for processing, and the results returned to the programmer.

(d) Our in-house programming capabilities were limited to small or slow segmented programs running on a HP-21OO.

(e) We had outgrown the capacity and capabilities of the equipment, therefore a change was needed.

WHAT WOULD SATISFY OUR FUTURE NEEDS?

The state of the art in mini-computers had reached a point of affordability and sophistication which would allow us to process the Autokon programs with time comparable to our present host computer, along with increased versatility. After evaluating several vendors we chose the Prime 400.

WHAT DID WE GAIN?

(a) We have a totally dedicated 24 hour a day computer.

(b) We have multiprogramming capabilities. All of the NC programmers can run their programs concurrently with scientific and hull calculation programs.

(c) Our time-sharing costs have been eliminated.

(d) We can serv as a host computer to our other offices.

(e) Our further program development and existing program implementation is no longer-restricted by a computer cost factor.

(f) We have the benefits of an interactive system over batch. Card input is eliminated along with the hours of turnaround time.

PRESENT SYSTEM, AND OUR USAGE

Our present system configuration:

(a) Prime 400-CPU with 512K Bytes

(b) Magnetic Tape Unit - 9TRK, 800BPI, 45IPS

(c) High Speed Line Printer - 600 LPM

(d) Paper Tape Reader/Punch

(e) 300MB Disk Drive and Controller

(f) Card Reader - 300 CPM

(g) CRT's - 10 units

Each programmer has his own CRT and assigned work area (UFD) on the computer. The UFD is where the programmer will input his part manuscripts. After the manuscripts have been checked for correctness, they are then executed and the results-can either be spooled to the line printer or the CRT. All of this can be accomplished without the programmer having to move from his location. Once the programmer is satisfied with the results, the plot file which has been created is stored in a plot UFD and can be plotted on the Gerber 1275 Drafting System; When a plot file is determined to be correct a paper tape of the file is punched out and verified.

This method of operation permits uicker turnaround not only in manuscript preparation but in the time spent on the computer, and reduces needless punching of paper tape just to check the results.

We have been working with the converted Autokon-71 programs on the Prime 400 since the first of March under actual production. The past three months we have had two N/C lofting contracts being worked completely on the Prime. During this time we have made the following accessment of the system:

(a). Constant computer cost overhead maintained

(b) Turnaround time from initial start of job to completion reduced by 30%-40%

(c) Effectiveness of each programmer has increased significantly with the apparent total computer usage of the interactive system.

(d) Scheduling of computer related junctions is easier

(e) Storage of completed input and Databases can be placed on magnetic tape in lieu of boxes of cards

In general, the transition was smooth with the end results being better than we expected. We feel we have a streamlined efficient computer system, which is easy to use and maintain.

Part II: Description of the System Selection and Conversion Effort

Two years ago, when Designers and Planners began to look for an inhouse computer system to run the Autokon-71 package, a list of requirements was formulated. It included the following primary items:

(a) The ability to allow multiple personnel to simultaneously execute any of the Autokon modules such as ALKON or

FAIR using an interactive CRT rather than a remote card based batch system.

(b) Allow a collection of engineering software, previously run on a Hewlett-Packard 2100, also to be simultaneously executed. This included programs dealing with" various ship's functions such as damaged stability, hydrostatics calculations and propellor/shafting design.

(c) Provide the necessary software for effective interactive processing - namely:

(1)' A flexible and secure filing system.

(2) A quality source editor for the manipulation of programs and data files.

(3) A reasonably-easy to use command language allowing non-computer personnel to effectively converse with the system.

(d) Allow the conversion of the Autokon modules to proceed as smoothly as possible. This necessitates, among other things, a large address space, at least 32 bit integer hardware and FORTRAN as harmonious as possible to Univac's "FOR" compiler.

(e) Do the above with accuracy, speed and minimum cost.

A total of six large minicomputer systems were intensively examined. These included:

(a) Harris 210

(b) Hewlett-Packard 3000 Series II

(c) Interdata 8/32

(d) Modcomp IV

(e) PDP-11/70

(f) and the Prime 400

After a very careful evaluation and study, the Prime 400 minicomputer system was selected. Prime Computer, Inc. is a relatively new company that builds a family of general purpose computers ranging from the single user 100 to the 400 and 500 which are large scale systems designed primarily for multiprogrammed interactive processing. Being based on the MULTICS system developed at MIT, a combination of demand paging and segmentation provides virtual memory with an address space for each user or process of up to 512 million bytes (This is a SYSGEN parameter which, on our system, is set to 2^{21} bytes or slightly in excess of one million 16-bit words per user).

Several other salient aspects of the Prime 400 hardware are:

(a) Dual register sets, a 2000 byte fast access cache memory and interleaved error correcting memory provide basic processor speed.

(b) Stack architecture allowing efficient recursion, a hardware implementation of the Dijkstra “P” and “V” operators and a micro-code implemented prioritized process dispatcher leads to an efficient operating system.

(c) “Rings of Protection” which is a generalization of the usual two state system (Restricted or user mode -vs- non-restricted or OS mode) to a hierarchial n-state system. Code in state “i” has access to code in states greater than “i” but no access (except via the-procedure call) to code in states less than “i". This leads to a secure protection mechanism.

(d) Programs operate in an environment consisting of a stack segment containing all local variables and procedure back-linkages a linkage segment containing statically allocated data and an instruction or procedure segment which, for pure reentrant code, may be shared among concurrent users thus decreasing paging overhead.

These features, combined with good interactive software, especially the tree-structured file system, the FORTRAN compiler and the source editor dictated the selection of the prime system.

Approximately six man-months were required to convert the Autokon-71 package to execute on the Prime system. The changes may be roughly divided into two groups: Those which were essentially cosmetic in nature and reflect known compiler or system differences and those which were significant alterations due to such non-obvious factors as differences in word lengths, I/0 handling and the libraries.

Primary cosmetic changes to the Autokon-71 source included:

(a) Pure Ansi-FORTRAN subscripts were required and DATA statements could not contain embedded implied loops.

(b) Inline code is generated for logical functions “AND”, “OR” and “NOT”. Therefore, all references to-procedures “IAND”, “IOR” and “NOTQ” were changed.

(c) Various constants defined usually in DATA statements were expanded to their full precision (SQRT(2.0) was 0.707 etc.)

(d) The Univac ’octal (“O”) format did not exist on the Prime necessitating the changing of many formats to the “I”

type. These were later changed back after the octal capability was locally added to the formatter to aid the interpretation of AUTOBASE dumps.

(e) Numerous procedures assumed - 36 bit integers. These were changed to reflect the Prime 32 bit hardware.

(f) Various other compiler differences were noted: For example, the FORTRAN statement K=-10**4 results in a different value for K on the Prime than on the Univac.

Primary non-cosmetic changes made to the Autokon-71 package included:

(a) The I/0 procedures were, of course, completely rewritten. These included IORAN, GARBO and GARBI in FAIR, DRAW and LANSKI as well as QREAD, QWRIT and QWAIT in the AUTOBASE package.

(b) Various machine language procedures also were rewritten. These included QGTNT, IBITQ and several others.

(c) Several of the programs which assumed an absolute floating point upper bound greater than that provided by the Prime hardware were modified.

(d) Prime, unlike Univac, requires that the link-editor encounter the largest occurance of a FORTRAN common block first. Therefore, in each of the Autokon-71 programs, all common blocks were defined in the main program which is linked first.

(e) The Prime system software had to be slightly modified to allow floating point overflows, divide checks, etc. The standard action is for a program stop. The FAIR test

acceptance case alone generated overflows on the 36 bit Univac.

(f) On the Prime, data areas are placed differently relative to each other than on the Univac causing subscript errors that previously destroyed inactive data to manifest themselves. In this respect, LANSKI gave the most problems followed' closely by ALKON.

(g) Approximately 7-8 decimal digits of accuracy is available on the Univac (Single Precision) as compared to 6-7 on the Prime (32 -VS- 36 bits). In ALKON, where large numhers are manipulated, a significant number of errors appeared forcing the decision to run various parts of ALKON in double precision. This resulted in little additional overhead in this very I/0 bound program. With the exception of a minor altercation in LANSKI, no other significant problems concerning numerical accuracy have appeared.

(h) In order to generate paper tape results with the Prime system, a utility program was written to punch and verify tape in either the ESSI or in the word address format. Depending on the requirements of the target flame cutting machine, various character sets in even, odd or with no parity setting may be used.

Now that the entire Autokon-71 package is operational and stable, an effort is currently being made to maximize the overall throughput and speed of the system. With this set of programs, the primary emphasis is on reducing I/0 through the following techniques:

(a) In order to reduce paging, the relative placement of the procedures are being altered to reflect the calling patterns. In general, the higher the probability that when a subroutine calls another routine they both are in in the same physical page, the lower the overall paging time will be.

(b) The Prime FORTRAN compiler generates reentrant pure code which, in order to reduce paging, may be shared among different users. That is, rather than having several copies of a large frequently used module such as ALKON simultaneously in memory, it is possible to have only one copy of the pure component concurrently shared.

(c) With close to 2 Mbytes of virtual space available to each user, rather than initiating true I/0 to and from the disc, an attempt is being made to modify the AUTOBASE package in order to bring a significant percentage of the active database into the address space. It is hoped that the paging time will slightly increase while the I/0 time will show a significant decrease.

In summation, the conversion of this relatively large and complex software package from the Univac 1100 to the Prime system went remarkably smoothly considering the differences in compilers, libraries and the hardware.

APPRENTICE--A PORTABLE WELDING ROBOT FOR THE SHIPBUILDING INDUSTRY

Torsten H. Lindbom
Unimation Incorporated
Danbury, Connecticut

Mr. Lindbom is Vice President in charge of research and development at Unimation Inc. He has 37 years of engineering experience, the last 16 years with Unimation Inc. Mr. Lindbom has a B.S. degree from Stockholm Technical Institute,

APPRENTICE - A PORTABLE WELDING ROBOT FOR THE SHIPBUILDING INDUSTRY

Introduction

To start with, the title of this paper is not correct: The Apprentice is not a robot! The Apprentice is a programmable welding manipulator, that the operator places where welding has to be done, programs the machine to do the job, and oversees the operation. The operator is in control of the operation, the Apprentice is merely a tool which increases the man's productivity. An industrial robot like the Unimate replaces the man and a Unimate is justified economically by the reduction of wages. The economical justification of the Apprentice is more difficult to specify. Since one man can oversee more than one Apprentice, his productivity is increased and less man hours are required for a given job. The Apprentice should then be justified by the more efficient use of man power, but also other considerations enter the picture. The Apprentice does an excellent job in out of position welding, something I personally cannot do, but I can program an Apprentice to do it - hence, the Apprentice unskills the job of the operator.

It is also willing to work in cramped quarters where heat and fumes make the job unpleasant for a man.

The Apprentice idea goes-back to 1971 when we took a look if our Unimate robot could be applied to the shipbuilding industry at which time we recognized that a stationary robot could do very little in a yard and a different approach was needed.

In 1975 Kockums Shipyard in Sweden showed an interest in our idea and-we jointly arrived. at a specification for the work they were doing building supertankers.

Description

The Apprentice weighs only 35 kg. It has five axes, is an electrically driven and numerically controlled machine. It has a polar coordinate system geometry with the weld torch attached to to the end of the arm.

At programming, a teaching device is placed over the weld torch. On the end of the device, is a wheel which guides the torch and arm along the path to be welded. The wheel generates pulses that trigger the recording of the positions of the five axis.

This same programming device also has a recording switch which is held depressed along the path where the weld is desired.

The welding in a section has to be done in a pre-determined sequence, and the conditions for each weld, such as, speed, weave amplitude, dwell, arc voltage, wire speed, etc., are preset on the control panels of the Apprentice and the welding power supply.

Once the sequence and the weld conditions have been determined, the only thing the operator has to do is to attach the teaching device to the torch, move the torch out of it's resting nest to the location to be first welded, press the wheel against the metal and roll it along the path to be welded while keepinq the weld recording switch depressed, release the switch, move the arm to the next point to be welded, make contact with the wheel, depress the weld recording switch, etc., and finally, place the torch in it's resting nest.

The Apprentice is now programmed and ready for welding. The whole operation only took a minute or two.

Experience to Date

A machine with these features was delivered to Kockums in November 1977 for evaluation. Unfortunately at that time Kockums were no longer building these large ships, and the Apprentice could not be tested in the yard on the job it was initially intended for. Instead, the Apprentice is now being used in building smaller ships.

Originally, at each location, the Apprentice had more than a 2.5 meter of welding to do, which took an arc time of about 50 minutes. In these small ships the weld at each location, is about one meter with a 20 minute welding time. Even with this short welding time Kockums found the Apprentice to be an advantageous tool.

As we have seen earlier the programming is easy and quick. The most time consuming job is to move the Apprentice from one location to the next. Kockums has solved this by using magnetic feet for the Apprentice and slides and other material handling devices to move the Apprentice across the longitudinal stiffners. The power supply, wire feeding equipment, smoke extraction system and the Apprentice control system are placed on a platform that is moved by a Crane to a central location from which the Apprentice can work within a radius only limited by the length of the cables (30 FT.).

We are now building a few pre-production models, some of which have been sold or committed to ship building or other heavy industrial applications. We hope to produce these machines in quantities in about a year from now. The price is estimated to be below $25,000.

Apprentice Robot Specifications

Working Envelope

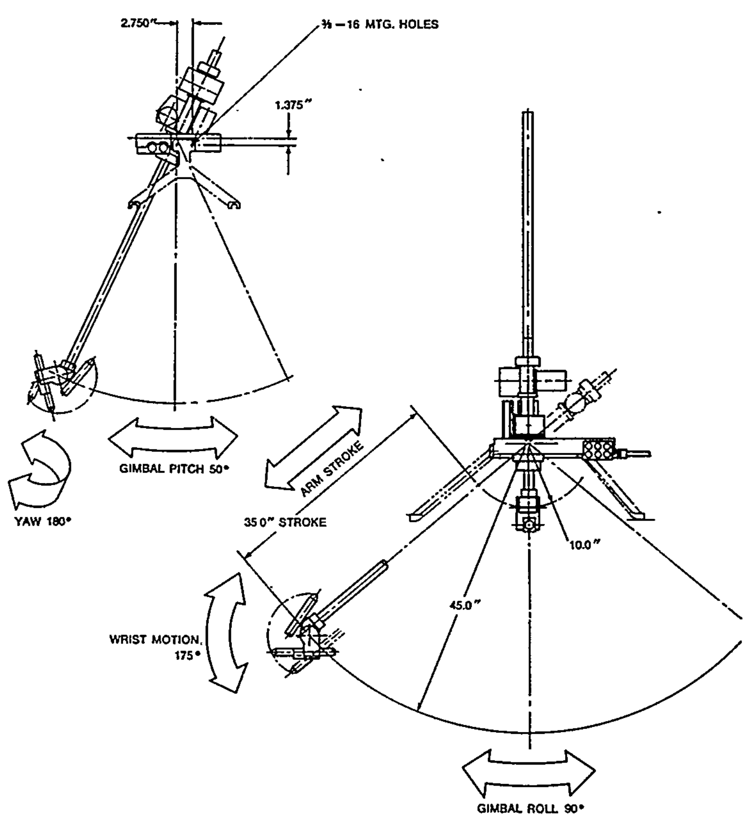
Arm stroke	35 inches
Gimbal, roll	90 degrees
Gimbal, pitch	50 degrees
Yaw	180 degrees
Wrist motion	175 degrees

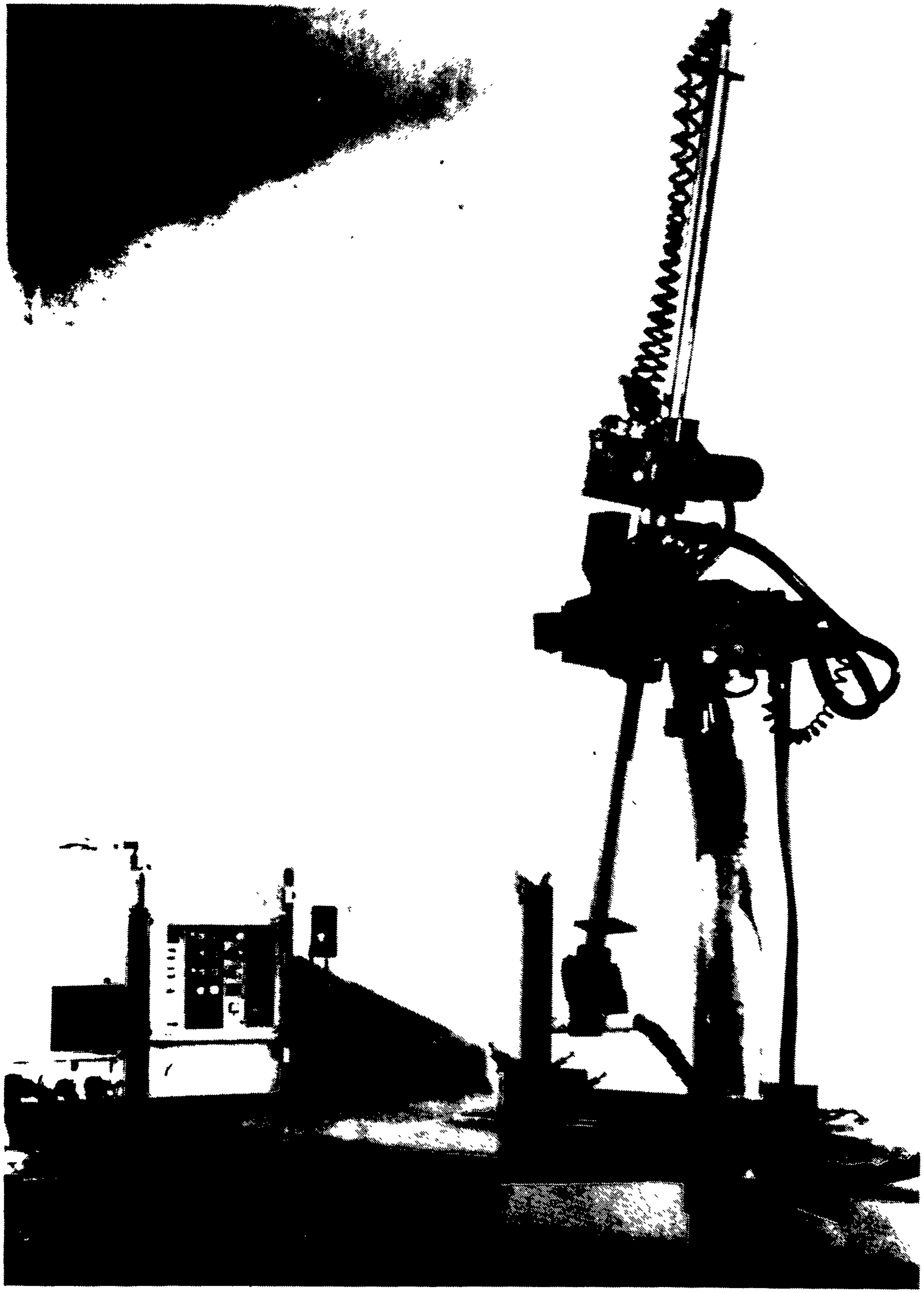
Performance:

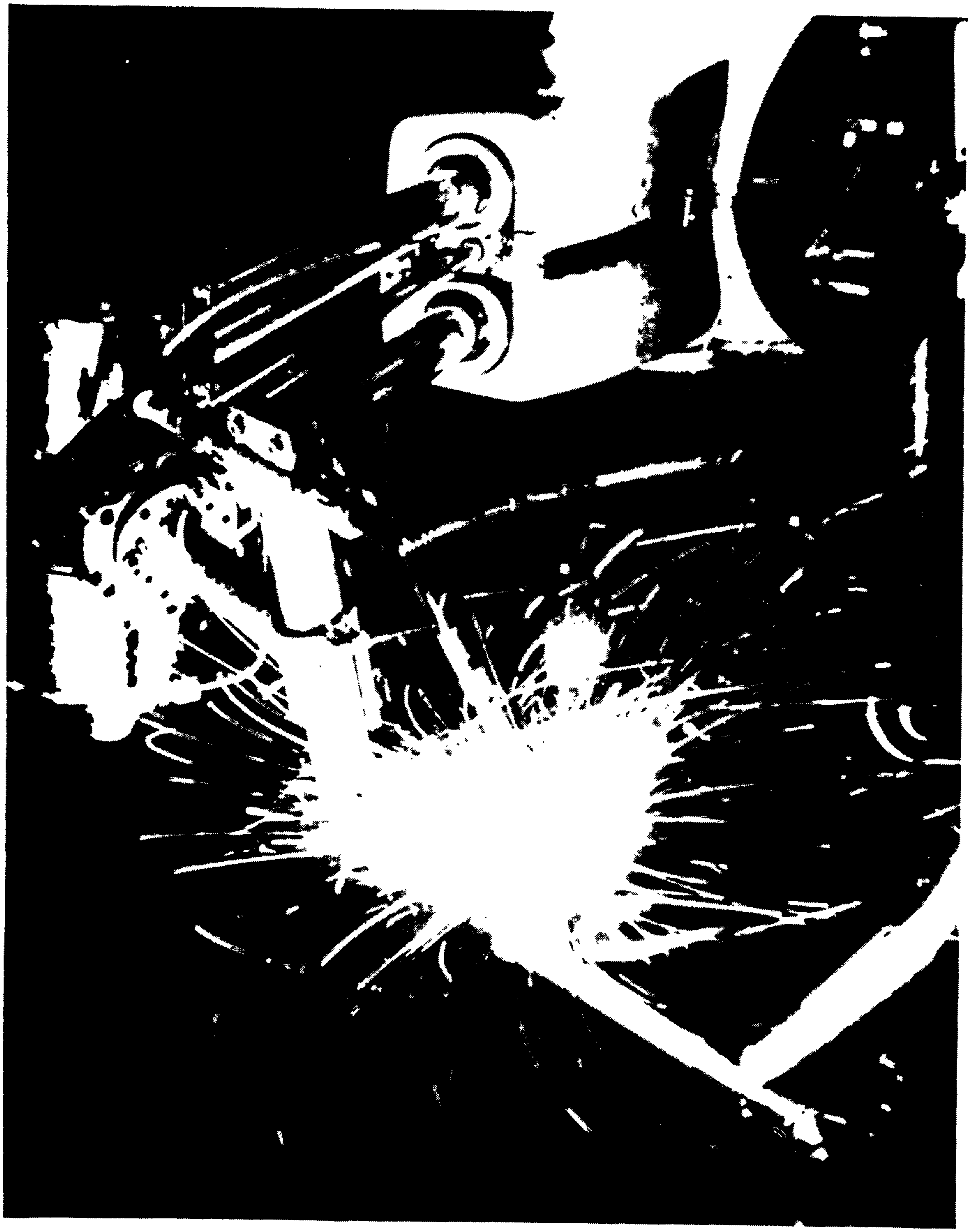
Welding speed	.4 in. to 8 in. per minute
No. of welding speeds	4
No. of preselect welding currents	4
Transfer speed	20 in. per second
Weave Channels	2
Weaving frequency	0.1 per sec. to 1 per sec.
Weaving amplitude	.08 in. to .80 in. peak to peak
Accuracy	± .04 in. max. deviation between taught welding path and the repeated path in automatic welding mode.
Weight of arm	75 lbs.
Weight of cabinet	175 lbs.

Cable length: 33 feet.

Power requirement:
240/480V, +10% −15%: Single phase: 60 Hz; 1KVA (other options available).







NSRP 0005

IMPROVING SHIPBUILDING PRODUCTIVITY THROUGH USE OF STANDARDS

John C. Mason
Bath Iron Works Corporation
Bath, Maine

Mr. Mason is currently responsible for the administration of the Shipbuilding Standards Research Program under the joint Bath Iron Works/Maritime Administration (MarAd) Ship Producibility Research Program. He also serves as Secretary of the Society of Naval Architects and Marine Engineers (SNAME) Panel SP-6, Standards and Specifications; and was recently elected Secretary of the new ASTM Committee F-25 on Shipbuilding.

Mr. Mason holds a B.S. degree in mechanical engineering from the U.S. Naval Academy and an M.S. degree in administration/management engineering from George Washington University.

IMPROVING SHIPBUILDING PRODUCTIVITY THROUGH USE OF STANDARDS

INTRODUCTION

The use of standards to improve productivity in the shipbuilding industry is not a revolutionary concept. In contrast to the European shipyards; however, (who have stated that they could not operate profitably without standards) and to the Japanese shipbuilding industry (which for more than 25 years has employed a sophisticated system of national industrial and individual company standards), the use of standards in this country to improve shipbuilding productivity has been limited.

In recent months significant progress has been made in implementing a National Shipbuilding Standards Program which has the potential for major improvements in productivity and reductions in cost in the U.S. shipbuilding industry. The objective of this brief paper is to provide an overview of the National Shipbuilding Standards Program effort and to illustrate the potential benefits of the use of standards.

BACKGROUND

In the summer of 1970, the Maritime Administration Office of Advanced Ship Development joined forces with the Ship Production Committee of SNAME (the Society of Naval Architects and Marine Engineers) in a joint venture to plan and finance research projects which would

reduce the time and cost of ship construction. One-of the principal efforts within the National Shipbuilding Research Program is the Ship Producibility Research Program sponsored by Bath Iron Works Corporation.

As a result of research conducted in the original "standardization" portion of the Ship Producibility Research Program between 1973 and 1976, and the findings of related research, it became clearly apparent that many aspects of the U.S. shipbuilding industry would benefit significantly from the coordinated development and use of industry standards. In October, 1976, a National Shipbuilding Research Program report was published entitled "Feasibility of Shipbuilding Standards". This report concluded that shipbuilding standards are technically and economically feasible, and recommended development and implementation of a National Shipbuilding Standards Program.

During 1977, planning was accomplished for a major redirection of the Ship Producibility Research Program to focus on the areas of Shipbuilding Industrial Engineering and Shipbuilding Standards. It should be noted that improved productivity, and therefore reduced cost, is also the prime objective of the Shipbuilding Industrial Engineering Program - specifically through the development and application of shipyard labor standards and other traditional I.E. techniques. Additional information on this program is available from either Frank Munger or Jim Helming, Bath Iron Works Corp., (207) 443-3311.

Implementation of a National Shipbuilding Standards Program began in November, 1977 with the reactivation of SNAME Panel SP-6, Standards and Specifications. Through this group an initial program of shipbuilding standards research projects was developed, and the American Society for Testing and Materials (ASTM) was selected as the best "system" for the development and ongoing maintenance of national shipbuilding standards.

MECHANICS OF THE NATIONAL SHIPBUILDING STANDARDS PROGRAM

ASTM COMMITTEE F-25 ON SHIPBUILDING

The American Society for Testing and Materials (ASTM), founded in 1898, is a non-profit management system for the development of standards on characteristics and performance of materials, products, systems, and services; and the promotion of related knowledge. It is the world's largest source of voluntary consensus standards; and is currently the administrative, legal, and publications arm for some 130 standards-writing committees. ASTM standards are submitted to ANSI (the American National Standards Institute) for parallel approval as American National Standards. (ANSI is not in the business of writing standards, but performs the function of national coordinator; ASTM is the major standards writing organization.) Recognizing the problem of semantics surrounding the word "standard", ASTM uses it as an adjective in conjunction with five (5) types of standards - standard specifications, test methods, definitions, recommended practices, and classifications.

On May 31 - June 1, 1978 over 175 senior representatives of all segments of the shipbuilding industry (shipbuilders, owner/operators, design agents, major vendors, regulatory and government agencies, and academia) met at ASTM Headquarters in Philadelphia and officially organized the new ASTM Committee F-25 on Shipbuilding. During this meeting the scope of the committee was defined, a technical and admin-

istrative subcommittee structure was approved, committee officers were elected, and the technical subcommittees met to establish initial membership, leadership, and the scope of each subcommittee's work[2] Anyone who has an interest in the work of this committee may join at any time, and, in fact, individuals interested in working on the various technical subcommittees are encouraged to join these now active groups as soon as possible by contacting the author.

As the technical subcommittees identify standards to be developed, task groups of 2 to 5 people are formed to do the required background work and actually prepare an initial draft, which is reviewed by its parent subcommittee through a balloting procedure. If the document is approved by two-thirds of those returning ballots (a minimum of 60% of voting interests must return ballots), the document proceeds to the main committee ballot. Here, 90% of those returning ballots (again a 60% return i-s required), must approve the document. It then goes to a Society ballot where a minimum of 50 ballots is required, and 90% must vote affirmatively to make it an approved ASTM standard.

SHIPBUILDING STANDARDS RESEARCH PROGRAM SUPPORT

In pursuit of the overall objective of reducing the cost and time of ship construction, the Ship Producibility Research Program with SNAME Panel SP-6 has implemented an initial group of research projects which will directly support the efforts of the new ASTM committee[3].

First, to establish a baseline for the research program and for the ASTM committee, Task S-20 - “A Compendium of National Shipbuilding Standards” constitutes a survey of three (3) major areas:

(1) identification of ’standards currently in use in the shipbuilding industry. In addition to the more familiar standards (e.g. ASME Boiler and Pressure Vessel Code, IEEE-45, etc.) this will include an index of existing shipyard standards, accepted practices, etc.;

(2) identification of existing national standards not currently used in the shipbuilding industry, which have potential application; and

(3) a survey of selected foreign shipbuilding standards (ISO[4], IEC[5], Japanese, Swedish, and West German) to determine potential application in the U.S.

The index of shipbuilding standards which results from this project will be made available to all interested parties as an invaluable aid in planning, priority setting, and avoiding potential duplication of effort. On the latter point, it is not the intent of either the research program or the ASTM committee to duplicate existing standards. Rather, it is envisioned that the new ASTM standards will simply reference valid standards as appropriate (e.g. ASME Boiler and Pressure Vessel Code), and will hopefully work hand in hand with the various regulatory requirements (e.g. ABS Guidelines for Building and Classing Steel Vessels).[6]

The second, and principal, effort within the shipbuilding standards research program is currently comprised of a total of eight (8) cooperative shipyard standards writing efforts. These are, for the most part, design/Construction standards for routine items (e.g. ladders, manholes, etc.), and have been structured to "prime the pump" by providing several draft standards to each of the ASTM technical subcommittees within the next twelve months.

Future development of standards through the shipbuilding standards research program, beginning with follow-on efforts to the projects in the initial package, will emphasize well defined Priorities for cost reduction and productivity improvements through the continued cooperative efforts of participating shipyards.

POTENTIAL BENEFITS OF STANDARDS

In general, attempts to describe or moreover, to quantify the benefits of using standards in the shipbuilding industry can be as frustrating as trying to eat an elephant between two slices of bread. For one thing, our industry is a very special and complicated system. Compounding this, the impact of even one simple standard might be described as a complex, three-dimensional ripple/multiplier effect. The following sections of this paper represent the author's attempt to first describe some of the secondary or "ripple" benefits of using standards, and secondly, to focus on some direct improvements in productivity.

SECONDARY BENEFITS OF STANDARDS

Assessing the full impact of the application of standards in the shipyard requires an appreciation of the entire management cycle as shown in Figure 1.[7] Some examples of the impact of standards in

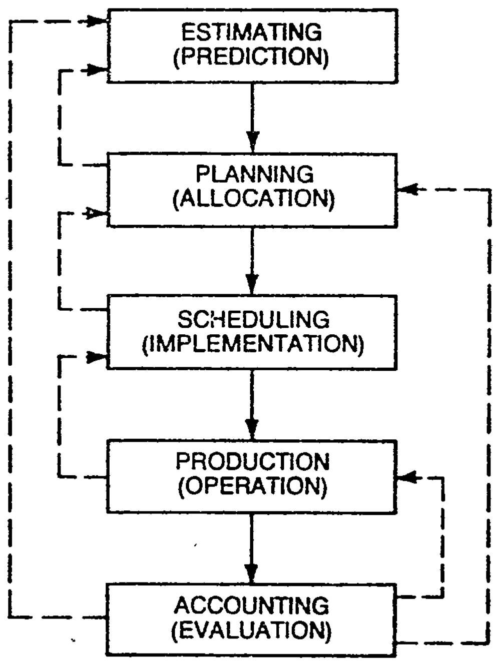


Figure 1 - Management Cycle

the general management cycle are:

- Reduced bidding costs - more accurate estimates
- More accurate planning and scheduling - less uncertainty
- Reduced design, engineering, approval and inspection cost
- Facilitation of automation - computer aided design and manufacturing

- Elimination of unnecessary variations in design factors and construction details
- Improved customer acceptance - clear communication
- Increased equipment reliability - reduced spares

DIRECT PRODUCTIVITY BENEFITS OF STANDARDS

Focussing now on the production or operations function of the shipbuilding management cycle, the objectives of this section are two-fold: (1) to describe in general terms some of the direct improvements in productivity which can be realized through the use of standards, and (2) to provide some specific, quantitative examples of potential productivity improvements and the related cost savings.

What are some of the direct productivity improvements which can be realized through use of standards? The following examples, certainly not all inclusive, are offered for consideration.

Reduced Shipyard Purchasing and Material Cost - the use of standard parts, components, and materials will result in fewer material line items, a reduction in inventory levels, improved material availability, potential quantity discounts, and general streamlining of the purchasing/material functions.

Reduced Shipyard Hours Due to Increased Production Efficiency - producibility will be an integral consideration in design/construction standards; definitive standards and the learning curve effect will result in improved quality (fewer errors

and less rejection/rework), shops will be more level-loaded due to improved planning and scheduling, special requirements (mock-ups, models, etc.) will be eliminated.

Facilitation of Batch Manufacturing - standards will encourage batch manufacture of parts for future use, or even sale to other yards; shops would be more level-loaded; scrap reduced through cross-nesting, etc.

Reduced Time, Contract Award to Production - the utilization of standards will simplify the post contract design, allowing shipyards to start work sooner on the contract, and let the design of modified areas proceed along with the construction.

How realistic are these potential benefits of using standards in shipbuilding? The following are selected specific examples which are the results of standards research projects and/or actual shipyard application.

(1) Rectangular Vent Duct Standards

Quoting the findings of this research project:[8]

1.3 Findings

Overall costs for rectangular vent duct installations in ships could be reduced significantly through the use of standards. For example a 20 c savings is estimated for such installations in a 75.000 DWT Panamax tanker. The savings are manifest in all of the required shipbuilding disciplines and mostly result from eliminating virtually all custom components and thus allowing a reduced number of line items both for purchased and in-process materials.

These standards are currently being used by Tacoma Boatbuilding Co. and J. J. Henry Co. in the design and construction of new class of USCG cutter.

(2) Propulsion Plant Standards

One of the original standardization research projects of Ship Producibility Research Program was the "Propulsion Plant Standards Feasibility Study" done by M. Rosenblatt & Son, Inc., under subcontract to Bath Iron Works Corp. The conclusions of that study were:[9]

> Development and implementation of propulsion plant standards is both feasible and desirable. Early emphasis should be on Total Plant Standards and Procurement Standards.
>
> The savings that can be realized from the application of these standards to a 26,000 SHP steam plant include:
>
> Labor savings of about $250,000 on the first ship in a series.
>
> Schedule savings of 5 months in the lead ship which would contribute additional savings on the first ship of $750,000.
>
> Schedule savings of 2 months on the second ship in a class, saving about $300,000, raising savings on a class to $1,300,000.
>
> Total savings on the class of 4 ships would be about 20% of the shipyard design and installation costs for the class.

For any one individual shipyard, these savings could be modified depending upon to what degree they have already standardized their designs and technical and procurement procedures.

Application of Total Plant Standards and Procurement Standards to the propulsion plants projected for the decade would save nearly $100 million on plants which will have an installed value approaching $2 billion. (Almost 5%.)

(3) Improved Design Process

One of the principal recommendations of this study under the Ship Producibility Research Program was "that the use of standards be substantially increased . . . to reduce design time and cost, minimize errors, reduce risk, and improve the product."[10] General Dynamics Corp., Quincy Shipbuilding Division (where the study was done) has successfully applied standardization of such items as tripping brackets and steel plate in their current series of LNG tankers.

(4) Standard 10 FT^3 Raq Locker

This final example of a 10 $ft.^3$ rag locker which was standardized by Avondale Shipyards, Inc. is intended to illustrate that even the most mundane items may offer the potential for productivity improvement and cost reduction through standardization. By standardizing the design and construction of this rag locker (normally one or two of these items are called for in the ship's machinery spaces), Avondale has been able to save the time and cost of some 70 direct

manhours of repetitive design effort - not to mention the input to the secondary impact areas mentioned in an earlier section. If an owner wants a 12 $ft.^3$ rag locker, certainly the standard can be modified - and the owner will pay the incremental cost involved. Not using standards for such items is almost analogous to an automobile manufacturer sizing the car's glove box to the individual buyer's specification.

CONCLUSIONS

In conclusion, the use of standards not only represents one of the most significant opportunities for productivity improvement and cost reduction in shipbuilding, but is also a necessary requirement in the development of automation in the industry.

Through the new ASTM Committee F-25 on Shipbuilding Standards the industry now has an effective vehicle for the development, coordination, implementation, and maintenance of National Shipbuilding Standards. Solid, broadbased support currently exists for the work of this committee, and with our real commitment to the program the benefits of standardization described herein can become a reality.

John C. Mason
Project Engineer
Bath Iron Works Corporation
700 Washington Street
Bath, Maine 04530
(207) 443-3311, Ext. 2115

FOOTNOTES

[1]The minutes of that meeting, which include a list of attendees, are available from: Mr. Robert D. Bauer, ASTM, 1916 Race Street, Philadelphia, PA 19103.

[2]The ASTM Committee scope, subcommittee structure, and slate of officers are included in Attachment (1) to this paper.

[3]A summary of the initial Ship Producibility Research Program ship building standards projects is included as Attachment (2) to this paper.

[4]International Organization for Standardization.

[5]International Electrotechnical Commission.

[6]Both ABS and the U.S. Coast Guard are actively involved as members of the new ASTM committee. Also, the U.S. Navy, through the Naval Ship Engineering Center, is actively participating on almost every technical subcommittee of ASTM F-25 in line with OMB directive for government agencies to participate in the development and use of industry standards as applicable.

[7] "Rectangular Vent Duct Standards" May 1977, National Shipbuilding Research Program, U.S. Maritime Administration in Cooperation with Todd Shipyards Corp., Seattle Division, p. 5.

81bid., P. 1

[9] "Propulsion Plant Standards Feasibility Study", August 1975, National Shipbuilding Research Program, U.S. Maritime Administration in Cooperation with Bath Iron Works Corp., p. IV-I.

[10] "Improved Design Process", April 1977, National Shipbuilding Research Program, U.S. Maritime Administration in Cooperation with Bath Iron Works Corp., p. IV-9.

ASTM COMIITTEE F-25 ON SHIPBUILDING

SCOPE

"THE DEVELOPMENT OF STANDARD SPECIFICATIONS, TEST METHODS, AND PRACTICES FOR THE DESIGN, CONSTRUCTION, AND REPAIR OF MARINE VESSELS, THIS COMMITTEE WILL COORDINATE ITS EFFORTS OTHER OTHER ASTM COMMITTEES AND OUTSIDE ORGANIZAT1ONS HAVING MUTUAL INTEREST,"

ATTACHMENT (1)

TECHNICAL SUBCOMMITTEES

HULL STRUCTURE	SHIP CONTROLS & AUTOMATION
HVAC	MATERIALS
MACHINERY	COATINGS
DECK MACHINERY	OUTFITTING
PIPING	SUPPORT OPERATIONS
WELDING	GENERAL REQUIREMENTS
ELECTRICAL/ELECTRONICS	

SLATE OF OFFICERS

CHAIRMAN	R. J. TAYLOR MANAGER TECHNICAL-TANKER DEPT, EXXON INTERNATIONAL CO,
FIRST VICE CHAIRMAH	H. S. SMITH MACHINERY & OUTFIT SUPERINTENDENT BETHLEHEM STEEL/SPARROWS POINT
.SECOND VICE CHAIRMAN	CAPT. C. B, GLASS, USCG CHIEF, MERCHANT MARINE TECHNICAL DIVISION
SECRETARY	J. C. MASON PROJECT ENGINEER BATH IRON WORKS CORP.

PANEL SP-6 STANDARDS & SPECIFICATIONS

AVONDALE SHIPYARDS

BATH IRON WORKS

BETHLEHEM STEEL/SPARROW POINT

GENERAL DYNAMICS/QUINCY

INGALLS SHIPBUILDING

LEVINGSTON SHIPBULDING

MARAD

N A S S C O

N A V S E C

SUN SHIPPBUILDING

INITIAL RESEARCH PROJECTS

- TASK S-20, "A COMPENDIUM OF SHIPBUILDING STANDARDS"

  CORPORATE-TECH PLANNING, INC.

- SHIPYARD PROJECTS

  BATH IRON WORKS

  TASK S-23, MECHNICAL CONSTRUCTION STANDARDS
  TASK S-25, HVAC CONSTRUCTION STANDARDS

  GENERAL DYNAMICS /QUINCY

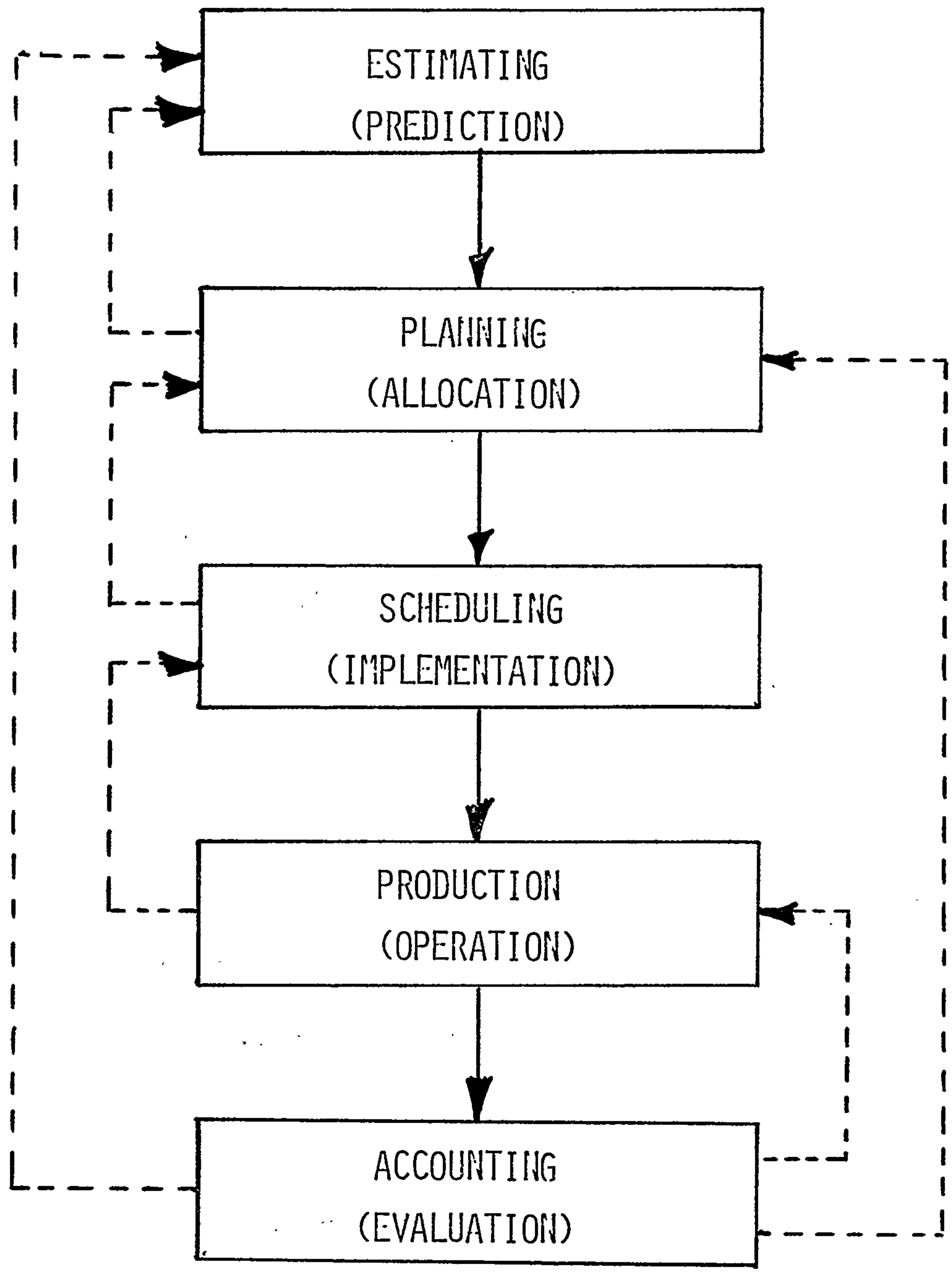
  TASK S-II, STANDARD STRUCTURAL ARRANGEMENTS

  NASSCO

  TASK S-24, MECHANICAL COKSTRUCTIOIN STANDARDS
  TASK S-26, ELECTRICAL CONSTRUCTION STANDARDS

  SUN SHIPBUILDING

  TASK S-21, SHAFT ALIGNMENT STANDARD
  TASK S-22, DEFECT TOLERANCE STANDARD
  TASK S-27, OUTFIT CONSTRUCTION STANDARDS


ESTIMATING
(PREDICTION)
PLANNING
(ALLOCATION)
SCHEDULING
(IMPLEMENTATION)
PRODUCTION
(OPERATION)
ACCOUNTING
(EVALUATION)

SUMMARY

SHIP PRODUCIBILITY RESEARCH PROGRAM

SHIPBUILDING STANDARDS PROJECTS

U.S. Department of Commerce

Maritime Administration

In cooperation with

Bath Iron Works Corp.

June 15, 1978

Attachment (2)

FOREWORD

Work in the shipbuilding standards portion of the Ship Producibility Research Program will be closely coordinated with the ASTM Committee on Shipbuilding Standards. The following initial research projects have been structured to provide some early contributions to the various subcommittees.

Task S-20, "A Compendium of Shipbuilding Standards"

Corporate-Tech Planning, Inc. of Portsmouth, NH will coordinate work on this project with the Executive Subcommittee. When complete, Task S-20 will provide input for general planning and decision making in the overall Shipbuilding Standards Program. The scope of the project includes:

- Identification of standards being used in the shipbuilding industry today.
- Identification of existing national standards not currently used in the shipbuilding industry, but which have potential application.
- Recommendations from a survey of selected foreign shipbuilding standards (ISO[1], IEC[2], Japanese, Swedish, and West German).

The following projects will be undertaken in order to provide early and diversified contributions to the development of standards by the various technical subcommittees:

[1]ISO - International Organization for Standardization
[2]IEC - International Electrotechnical Commission

Task S-11, "Standard Structural Arrangements"

(Hull Structure Subcommittee)

General Dynamics/Quincy Shipbuilding Division is nearing completion of a group of recommended standards which include:

- Tripping brackets
- Alignment criteria
- Clearance cuts
- Snipes
- Tight collars
- Reeving slots
- Structural intersections
- Miscellaneous cut-outs
- Patches
- End connections
- Face plates
- Chocks
- Panel stiffeners
- Clip connections
- Beam brackets

Task S-21, "Line Shaft Alignment Standard"

(Machinery/Piping or General Requirements Subcommittee)

Sun Shipbuilding & Drydock of Chester, PA will coordinate the development of draft standards which specify realistic recommended techniques and tolerances for shafting alignment. Propulsion systems to be addressed are:

- Geared steam turbine, inboard shafting
- Slow speed diesel, outboard shafting
- Geared steam turbine, outboard shafting

Task S-22, "Defect Tolerance Study"

(Hull Structure or General Requirements Subcommittee)

Sun Shipbuilding will coordinate the development of draft standards for industry-wide, engineered defect acceptance standards which will ultimately result in significant cost reduction.

Task s-23, "Mechanical Design/Construction Standards-Group I"

(Machinery/Piping Subcommittee)

Bath Iron Works Corp. of Bath, Maine will coordinate the development of an initial set of draft mechanical construction standards and engineering guidelines. Items included are:

- Pipe welding
- Instrumentation piping details
- Insulation usage and application data
- Branch connection usage tables
- Gage boards
- Pipe hangers
- Slip-on welding sleeves for steel pipe
- Cleaning and flushing of ship's piping systems
- Electrical, machinery, and piping test memo development and utilization
- Interface control procedures for shipboard automation
- Guidelines for preparing,Sea Trials Agenda, acquisition of special trials instrumentation, and organizing a ship's trial crew.

Task s-24, "Mechanical Design/Construction "Standards-Group II"

(Machinery/Piping Subcommittee)

National Steel and Shipbuilding Co. of San Diego, CA will

coordinate the development of an additional set of draft mechanical construction standards. Items included are:

- Bolting usage table
- Piping system diagram preparation
- Bolted and insulated watertight bulkhead and deck connections
- Steel flange, faced with monel inlay
- Funnels
- Welded bulkhead and deck sleeve watertight and oiltight penetrations for steel structure for ferrous and non-ferrous pipe
- Commercial steel air receivers
- Commercial steel potable water tank
- Commercial steel hot water tank
- Steel reinforcing sleeves for non-tight bulkhead and deck
- Expanded pipe socket silver brazing joint for tubing and IPS pipe
- Insulated watertight bulkhead and deck connections for steel structure (250° max.)

Task s-25, "HVAC Design/Constructiion Standards"

(HVAC Subcommittee)

Bath Iron Works Corp. will coordinate the development of an initial set of draft HVAC design and construction standards. Items included are:

- Drafting standards - hull, outfit, and HVAC
- Procedure for volumetric testing
- Gooseneck
- Watertight covers
- Structural penetrations

- Type "JA" terminal
- Ventilation flanges
- Elbows with splitters including veins
- Duct hangers
- Balance damper
- Wire mesh details
- Flexible connections
- Bolted access plates
- Lashing hook for canvas cover
- Hinged access door
- Methods of flanging acoustical ductwork
- Typical duct ratproofing details
- Hinged fire closure
- Fire dampers
- Type "E" terminal
- Typical grilled and diffuser connections
- Sliding damper
- Quick-action flange

Task s-26, "Electrical Construction Standards".

(Electrical/Electronic Subcommittee)

National Steel and Shipbuilding Co. will coordinate the development of an initial set of draft electrical construction standards. Items included are:

- Installation methods - electrical cable and equipment
- Cable penetrations of Class A, B, and frame tight bulkheads and decks
- Mounting of electrical boxes and cable supports using welded studs

- Mounting light fixtures
- Cable entrances to watertight and non-watertight equipment
- Cable penetrations and electrical equipment mounting in refrigerated spaces
- Cable hangers
- Multi-cable transit details
- Cable penetrations of Class B draft stops
- Methods of grounding equipment and cables
- Water sealing and end sealing of cable

Task s-27, "Outfit Construction Standards"

(Outfitting Subcommittee]

Sun Shipbuilding will coordinate the development of an initial set of outfit related construction standards. Items included are:

Bilge keel details - typical welded construction

Standard air and drain holes design in tanks

Manholes

Selected welding details

Vertical ladders and grabs

Rails (open storm and guard)

Machinery space floor plates and handrails - typical construction and installation details

Inclined ladders

Surface preparation and application of inorganic zinc

Contacts for Additional Information:

Ship Producibility Research Program
Bath Iron Works .Corp.
John C. Mason (207) 443-3311, ext. 2115

Task S-20
Corporate-Tech Planning, Inc.
James A. Burbank (603) 431-5740

Tasks s-21 and S-22
Sun Shipbuilding & Drydock Co.
Dr. Richard Bicicchi (215) 876-9121, ext. 8310

Tasks s-23 and s-25
Bath Iron Works Corp.
Walter Orlovsky (207) 443-3311, ext. 2760

Tasks s-24 and s-26
National Steel and Shipbuilding Co.
George A. Uberti (714) 232-4011, ext. 604

USER GUIDE TO INTERACTIVE LINES GENERATION (HULGEN) WITH A STORAGE TUBE

Arthur L. Fuller
Advanced Design Branch
Naval Ship Engineering Center

Mr. Fuller is Supervisor Naval Architect, Head Computer Applications Unit (6114B2). He is currently responsible for management of the R&D analysis, coordination, development, implementation, and maintenance of computer aided design tools for early stage naval ship design. Mr. Fuller has 18 years experience in computer aided ship design development.

1.0 INTRODUCTION

Given the very minimum input of length, beam, draft, prismatic and midship section coefficients, LCB, LCF, and a deck at edge definition; HULGEN computes all of the initial parameters and control curves required to produce a body plan. This body plan is not the one desired, but provides a starting point for any variations the user wants to make.

The SHIP HULL FORM GENERATOR (HULGEN) uses a piecewise polynomial development and representation of an early stage design ship's body plan. It was originally written for refresh. graphics scopes with light pens. Those earlier versions of the program, although done for light pen picks, operated in a way that made conversion to storage tube graphics very practical. The displays were changed very little and the interactive light pen picks were converted to keyboard entry menus. The user now types a menu option and/or data to proceed.

HULGEN was developed specifically for the early stage design problem of developing many optional hulls rapidly. At this point in the design it is important to be able to determine whether the desired hull form can be developed from the gross dimensions and form coefficients available. Hull form generation is distinguished from hull lines fairing in that the output is a visually smooth body plan which meets the desired ship dimensional parameters. The various control curves and resulting body plan are mathematically smooth but not fair in the traditional sense.

2.0 GENERAL DESCRIPTION

A detailed description of the mathematical development, computer programming, and program operation can be found _in references 1 and 2.

Essentially, HULGEN provides the capability to produce a station cut of offsets at any point from the tip of the bow to the aft perpendicular. These cuts are produced by three polynomials. A third order polynomial is used to produce the offsets from the main deck at edge to load waterline. The offsets from the load waterline to the flat of bottom are produced by a specially developed fourth order polynomial for fine sections and by a bilge radius circle for full stations. As the program progresses from fine sections to full it adjust for the transition from one type curve to the other. It should be noted that this is not just a wire frame body plan, but one where every point on the surface is uniquely defined and can be computed with the appropriate station waterline intersection.

HULGEN produces only a set of molded lines representing the hull above the baseline. It will, handle a variety of bow, flat of bottom, keelrise,, and stern configurations, and a bulbous bow. It must be kept

in mind that HULGEN was developed by and for U.S. Navy type hulls. It has been used on the full gamut of “conventional” Navy hull forms for several years.

The body plan is produced from the following control curves:

Section area
Flat of bottom or halfsiding .
Load waterline
Main deck at edge
Profile
Deadrise slope
Load waterline slope
Main deck at edge slope

These curves are made up of one or more polynomials selected especially to represent the particular curve over a specified length of the hull. The section area and load waterline curves polynomial representations can be modified by the application of tension factors along their length. This feature was added to the program about two years ago to provide more flexibility to the user in the development of the hull .

HULGEN INPUT

The input is divided into the following three groups:

1. HULLFORM PARAMETERS - The dimensional parameters and hull form coefficients described in paragraph one of the introduction and the review'. hull 'input frame (3.4). This data is prepared by the user.

2. BOUNDARY CONDITIONS 1 - The points, slopes, coefficients, and other data required by the program to produce the control curves and the body plan. These are initially produced by the program and become the interactive parameters.

3. BOUNDARY CONDITIONS 2 - Input/output/display control and additional hull form parameters and boundary conditions resulting from modifications and additions to the program. This data is also initially generated by the program and becomes interactive input.

The “punch BND COND 1 + 2” output punches a complete set of the above data which can be used to recreate the body plan and control curves for any future use.

3.0 RUNNING THE PROGRAM

To run HULGEN, the user prepares a set of hull form parameters or obtains an existing data set and loads them on the computer. He then logs onto the system and attaches the HULGEN program and the data file.

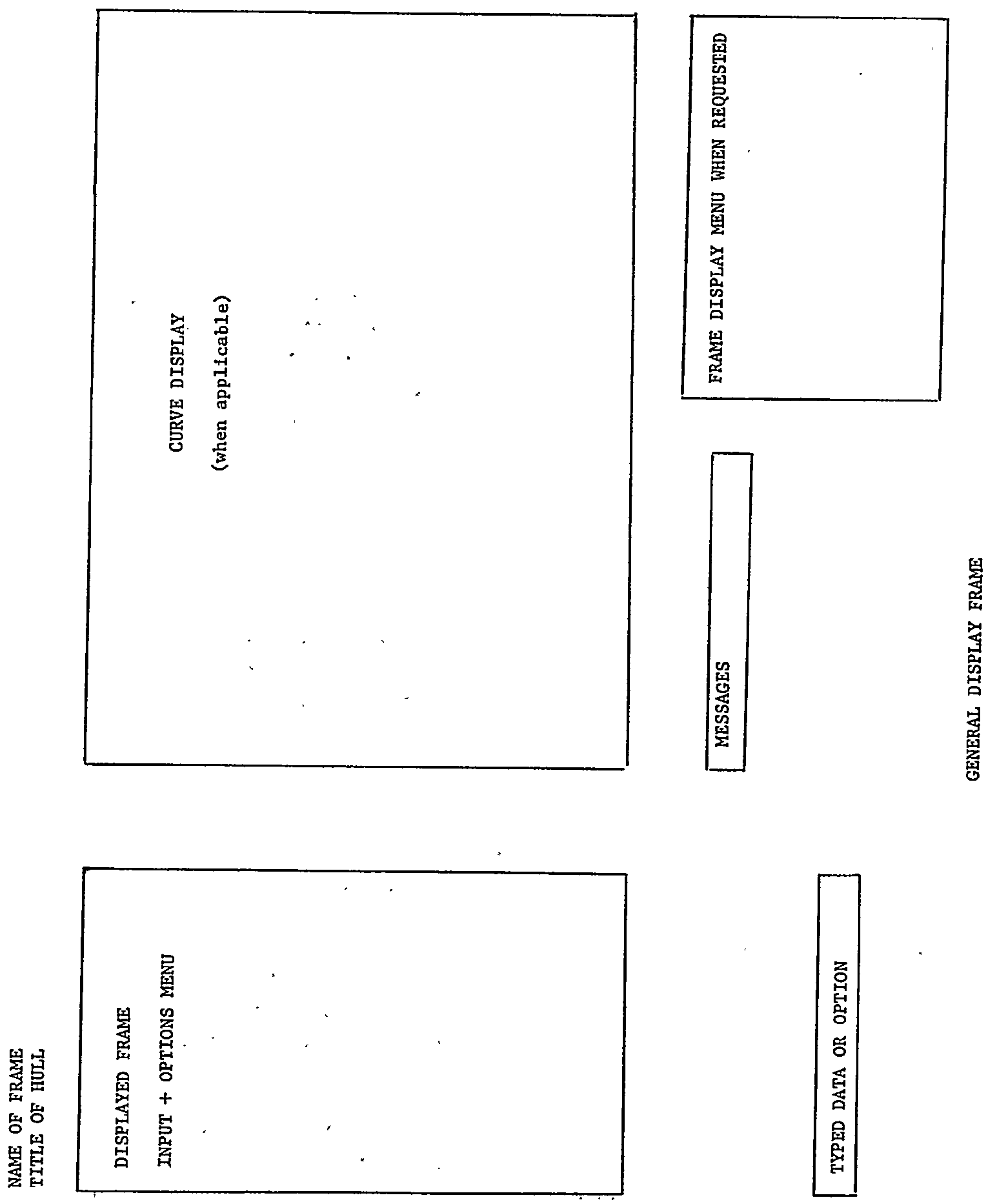


FIG. 3.0 GENERAL DISPLAY FRAME LAYOUT

After this, the first frame appears on the scope and user selects the desired option. Usually, the first option would be the display of the body plan from which a determination is made as to which control curve needs modification.

The following section of the paper gives a description of each display frame, its interactive input options and a sample picture of the frame.

When selecting an option from the frame display menu, only the first two characters of the name are required.

To change interactive data on the currently displayed frame, type in as many (option number, data value) pairs as desired and RETURN.

3.1 HULL FORM GENERATOR FRAME

This is the first frame that appears when the program begins execution. This frame provides space for advertising and space for miscellaneous messages to users.

To exit from this frame and continue to the Review Input,.Data,Frame... hiT RETURN.

For Experienced Users:

It is possible to save a little time by typing in the read options for the review input frame before actually entering the frame.

Example: Type 2, 1, 3, 1 and RETURN will cause reads of hull form data (automatic), boundary conditions 1, and boundary conditions 2. A RETURN alone gives only the automatic read hull form data option.

3.2 MENU OPTION - MENU

On all frames - Type menu or M to get
prompter message for the
various frames and options.

The menu option prints a list of the display frames available in the program. This list can be produced at any time by typing "menu" or "M". A shift from the current frame to another frame makes the list disappear.

The next page shows this option as requested from the hull form generator frame.

HULL FORM GENERATOR
ADVANCED DESIGN BRANCH

CODE 61148

NAVAL SHIP ENGINEERING CENTER

IN CASE OF PROBLEMS - CONTACT

FOR HELP T’fPE - RENU

HULL FORM GENERATOR
ADVANCED DESIGN BRANCH

CODE 6114B

NAVAL SHIP ENGINEERING CENTER

IN CASE OF PROBLEMS - CONTACT

MENU
MENU

FOR HELP TYPE - MENU

FOR	TYPE
REVIEW INPUT DATA	DATA
REVIEW HULL INPUT	INPUT
REVIEW SA CURVE	AREA
REVIEW DWL CURVE	DWL
REVIEW DKEDGE CURVE	EDGE
REVIEW PROFILE CURVE	PROF
REVIEW BOTTOM CURVE	FLAT
REVIEW SLOPES-DWL	SWSLP
REVIEW SLOPES-DEADRS	SDSLP
REVIEW SLOPES-DKEDGE	SESLP
REVIEW BODY PLAN	BODY
REVIEW OUTPUT OPTION	OUT
REVIEW TENSOR AREA	TAREA
REVIEW TENSOR DWL	TDWL
PROGRAM STOP	STOP
RESTORE OLD CURVE	OLD
CHANGE TITLE	TITLE

1

3.3 REVIEW INPUT DATA - DATA FRAME

The input data file can be manipulated so that the user can search for records representing hull form and boundary condition data required for a particular application. A read of a particulaR data type (1, 2, or 3) simply picks up the next data set in the file of that type.

Definitions for Frame - Review Input Data

1. READ HULL FORM DATA (HFP)

   Upon entering this frame for the first time, the first set of hull form data is read in automatically. At this point the user can display the body plan if desired. NOTE: If this is the first use of the HFP data,type "BODY" to have the program generate the boundarry condition data for you. It is a good idea to display all of the control curves at this time to assure that all coefficients have been computed. Set this option to 1 (type 1, 1) to activate the second and subsequent hull form parameter reads from your data file. The program returns 99.000 upon successful completion. It returns 1.0 when no data record of this type is found in file.

2. **READ BND COND No. 1 (Bcl)

   This data will have been created by an earlier run of HULGEN. Set to 1 to activate. Returns 99.000 upon successful completion. Returns 1.0 when data record is not found in data file. When running HULGEN, you should periodically "punch BND CND 1 + 2" (see output options frame) to save this data in case a restart is necessary. **CAUTION- When reading boundary conditions, check the title to make sure it matches your hull form parameters title. If the data file does not contain boundary condition values for your hull form parameters, this option will simply read the next available set.

3. **RED BND COND No. 2 (BC2)

   These boundary conditions are unique to the new version of HULGEN. Running without this data record makes the program behave like the old HULGEN program. This data defines station locations, points per station, and bow and stern boundary conditions.

   Set to 1 to activate. Returns 99.000 upon successful completion. Returns 1.0 when data record is not found in data file. **CAUTION - Same as above.

4. NOT USED

5. NOT USED

6. REWIND INPUT FILE

REVIEW INPUT DATA
MCM N.2 14 DEC 77

1. READ HULL FORM DATA 99.000
2. READ BND COND NO 1 0.
3. READ BND COND NO 2 0.
4. 0.
5. 0.
6. REWIND INPUT FILE 0.

2,1,3,1

FIG. 3.3.1 REVIEW INPUT DATA FRAME

REVIEW INPUT DATA
MIKE/ROD TEST PROB 8/4/7

1. READ HULL FORM DATA 99.000
2. READ BND COND NO 1 99.000
3. READ BND COND NO 2 99.000
4. 0.
5. 0.
6. REWIND INPUT FILE 0.

FIG. 3.3.2 REVIEW INPUT DATA FRAME WITH RESULTS

REVIEW INPUT DATA
MIIKE/ROD TEST PROD 8.4/

1. READ NULL FORM DATA 99.0000 99.000
2. READ BND COND NO.1 99.000
3. READ BND COND NO 2 99.000
4. 0.
5. 0.
6. REUIND INPUT FILE 0.

APEAI

FIG. 3.3.3 REVIEW INPUT DATA FRAME WITH TRANSFERED TO AREA

Set to 1 to activate. Returns 99.000 upon successful completion. The user may rewind the input data file at any time. If a rewind is specified, along with other reads. The rewind is performed first before the requested reads. The rewind is not always necessary. The program searches end around thropgh the file. This means that if a data record is not found before the end of file is reached, the file rewinds and begins to search through the file again. The program searches the file twice for a particular data record. When a data record is not found, the value returned is 1.000 instead of 99.000 for the particular requested read option.

The particular option can be selected by typing in the identification number of the option selected, a comma, and a 1. Two or more options can be strung together by typing a comma and another pair of numbers for identification and option setting 1.

Examples:

2, 1	Read BND COND No- 1
2, 1, 3, 1	Read BND COND No. 1 and
	Read BND COND hlo. 2
1, 1, 2, 1, 6, 1	Read HULL FORM DATA and
	Read BND COND No. 1 and
	REWIND INPUT FILE

NOTE : REWIND INPUT FILE, when requested, occurs before any concurrent read options.

A 99.000 is returned when the option selected is successfuly executed.

A 1.000 is returned when the option cannot be executed, i.e., no data record is available for option selected.

3.4 REVIEW HULL INPUT - INPUT FRAME

This frame presents the hull form data record currently in use by the program. The user can review and alter any or ,all data presented by the program.

Definitions for Frame - Hull Form Parameters

1. LEN BET PERPENDICULAR

The length between perpendiculars (dimensional)

2. BEAM AT STA MAX AREA

The beam on the design waterline at the station of maximum area (Dimensional)

3. DRAFT

Draft of ship at station of maximum area (dimensional)

4. MAX SECT COEF

Maximum section coefficient, CX (non dimensional)

5. DEPTH - STA O

Depth from keel line to sheerline at station 0 (dimensional)

6. DEPTH - STA 3

Depth from keel line to sheerline at station 3 (dimensional)

7. DEPTH - STA 10

Depth from keel line to sheerline at station 10 (dimensional)

8. DEPTHh - STA 20

Depth from keel line to sheerline at station 20 (dimensional)

9. NOT USED

10. NOT USED

11. NOT USED

12. HALF SIDING WIDTH

Width of half siding (dimensional)

To alter a data value or several values at once, proceed as follows:

Type in the identification number of the data value - located to the left of the alphanumeric description of the value, a. comma, and the new value. We will call this the ID, value pair. Several values can be changed simultaneously by continuing to type in ID, value pairs separated by commas. The maximum number of values the program will tolerate is 5 value pairs at a time.

```
HULL FORM PARAMETERS
MCM N.2 14 DEC 77

1. LEN BET PERPENDICLR 239.500
2. BEAM AT STA MAX AREA 43.960
3. DRAFT               11.877
4. MAX SECT COEF       0.840
5. DEPTH - STA 0       0.
6. DEPTH - STA 3       31.730
7. DEPTH - STA 10      29.360
8. DEPTH - STA 20      29.500
9. LRDK LENGTH-NOT USED 0.
10.RDK HEIGHT -NOT USED 0.
11.DISPLACEMENT-NOTUSED 1725.000
12.HALF SIDING WIDTH   0.500
```

FIG. 3.4.1 HULL FORM PARAMETERS FRAME

```
HULL FORM PARAMETERS
MCM N.2 14 DEC 77

1. LEN BET PERPENDICLR 239.500
2. BEAM AT STA MAX AREA 43.960
3. DRAFT               11.877
4. MAX SECT COEF       0.840
5. DEPTH - STA 0       0.
6. DEPTH - STA 3       31.730
7. DEPTH - STA 10      29.360
8. DEPTH - STA 20      29.500
9. LRDK LENGTH-NOT USED 0.
10.RDK HEIGHT -NOT USED 0.
11.DISPLACEMENT-NOTUSED 1725.000
12.HALF SIDING WIDTH   0.500
```

FIG. 3.4.1 HULL FORM PARAMETERS FRAME WITH VALUES TYPED

```
HULL FORM PARAMETERS
MCM N.2 14 DEC 77

1. LEN BET PERPENDICLR 239.500
2. BEAM AT STA MAX AREA 44.000
3. DRAFT               12.000
4. MAX SECT COEF       0.840
5. DEPTH - STA 0       0.
6. DEPTH - STA 3       31.730
7. DEPTH - STA 10      29.360
8. DEPTH - STA 20      29.500
9. LRDK LENGTH-NOT USED 0.
10.RDK HEIGHT -NOT USED 0.
11.DISPLACEMENT-NOTUSED 1725.000
12.HALF SIDING WIDTH   0.500
```

FIG. 3.4.3 HULL FORM PARAMETERS FRAME WITH RESULTS

Examples:

2,44.00	One ID value pair
2,44.00,3,12.00	Two ID, value pairs
2,44.00,3,12.00,1,250.253	Three ID, value parts

3.5 REVIEW SA CURVE:- AREA FRAME

Review section area curve and the parameters that effect its characteristics.

Definitions for Frame - Section Area Curve

1. PRISMATIC COEF - CP

   Non-dimensional' shape coefficient below the DWL. It is defined as the molded volume of displacement/(beam draft* length between perpendiculars X midship section coefficient).

2. LCB - PERCENT LBP

   Longitudinal center of buoyancy expressed as a percent of the length between perpendiculars referenced to midships. A positive value means the center is forward of midships, and a negative value means the center is aft of midships.

3. STA MAX AREA

   The longitudinal location of the section of maximum area expressed as a station location between 0 and 20.

4. STA 0 - AREA

   Ordinate of the section area curve at station 0 (forward prependicular) expressed as a fraction of the maximum section area.

5. STA 0 - SLOPE

   The slope of the section area curve at station 0 (forward perpendicular). It is non-dimensionalised on the maximum section area and the length from station 0 to station 10 (one-half LBP).

6. STA 20 - AREA

   Ordinate of the section area curve at station 20 (aft perpendicular) expressed as a fraction of the maximum section area.

7. STA 20 - SLOPE

   The slope of the section area curve at station 20 (aft perpendicular). It is a non-dimensionalised on the maximum section area and the length from station 10 to station 20 (one-half LBP).

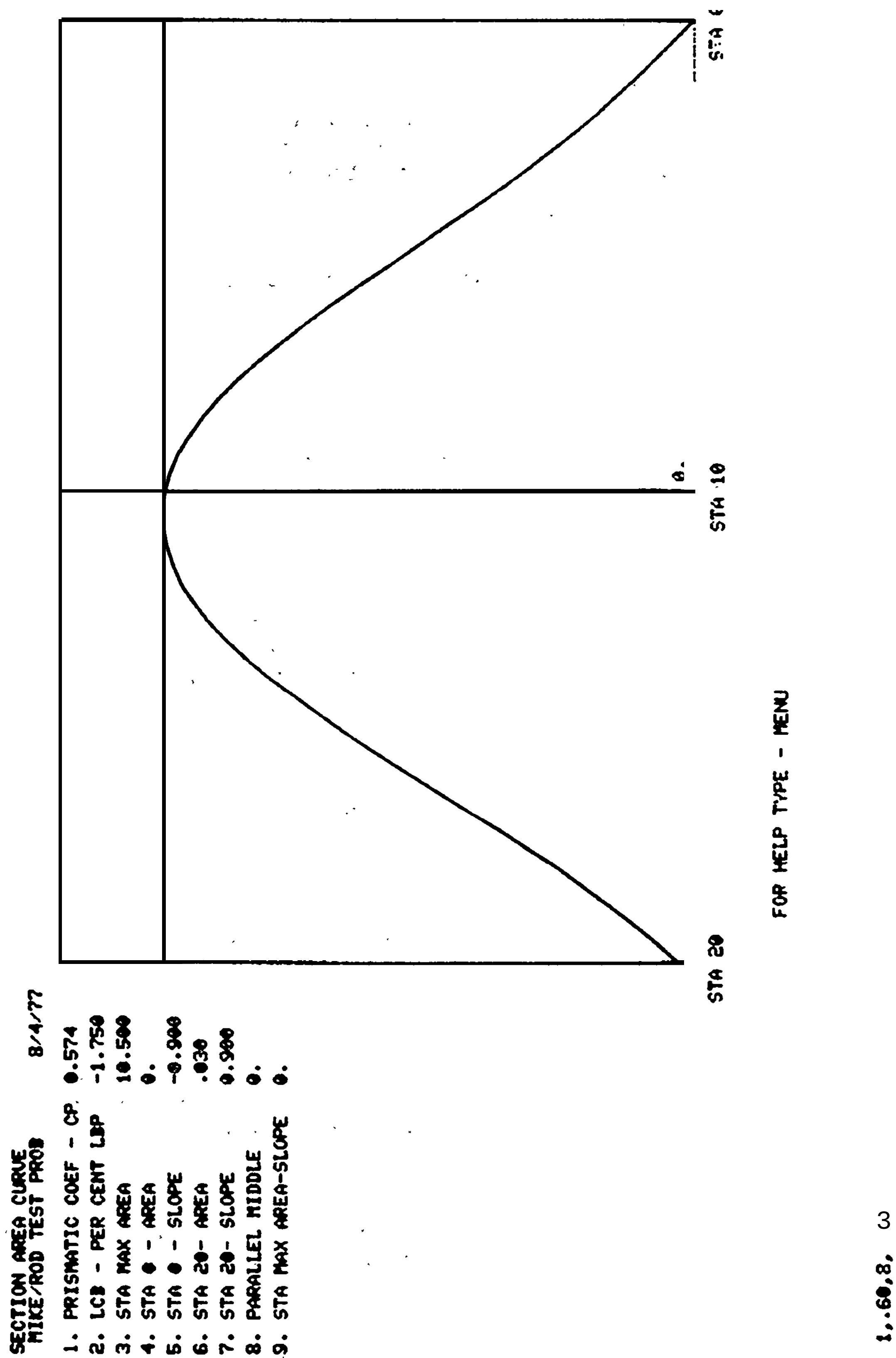


FIG. 3.5.2 SECTION AREA CURVE **FRAME WITH VALUES** TYPED

8. PARALLEL MIDDLE

The length of an optional flat portion in the section area curve expressed as a fraction of the length between perpendiculars.

9. STA MAX AREA - SLOPE

The slope at the station of maximum area is defined as 0.0. Do not change this value unless some unusual effect is required.

Review Tensor Area - TAREA Frame

The user has available a sensitive method to “fine tune” small changes into the section area by using tensor vector mathematics. Experimentation is required to determine the limits on the parameter alterations allowable.

In This Mode the Following Variables Appear:

Additional Definitions for Frame - Tensor Area Curve

10. TENSOR - STA 0

This parameter expresses the amount of “pull” on the forward part of the curve at station O along a direction line specified by the station O slope.

11. TENSOR - END.FWD SEGMT

This parameter expresses the amount of “push” on the forward part of the curve at the end of the forward segment along a directional line specified by the slope at the station of maximum area.

12. TENSOR - START AFT SEG

This parameter expresses the amount of “pull” on the after part of the curve at the forward end of the segment along a direction line specified by the slope at the station of maximum area.

13. TENSOR - STA 20

This parameter expresses the amount of “push” on the after part of the curve at the after end of the segment along a direction line specified by the slope at station 20.

3.6 REVIEW DWL CURVE - DWL FRAME

Review the non-dimensionalized design waterline and the parameters that affect its shape, area, and centroid of area.

Definitions for Frame - Load Waterline

1. WATER PLANE COEF

   This is the area-coefficient defined by the area of the water plane/(beam X length between perpendiculars).

2. LONG CTR OF FLOAT

   The longitudinal center of area expressed as a fraction of the length between perpendiculars. The center is referenced to station 10 (midships). A positive value means the center is forward of station 10 and a negative value means the center is aft of station 10.

3. STATION MAX OFFSET

   The longitudinal location of the maximum beam expressed as a station location.

4. STATION 0 OFFSET

   The offset at station 0 expressed as a fraction of the maximum beam.

5. STATION O SLOPE

   The slope at station 0 non-dimensionalized on the maximum beam and the length between station 0 and station 10 (one-half LBP).

6. STATION 20 OFFSET

   The offset at station 20 expressed as a fraction of the maximum beam.

7. STATION 20 SLOPE

   The slope at station 20 non-dimensionalized on the maximum beam and the length between station 10 and station 20 (one-half LBP).

8. PARALLEL MIDDLE

   The length of an optional flat portion on the DWL curve expressed as a fraction of the length between perpendiculars.

9. STATION MAX A SLOPE

   The slope on the DWL curve at the station of maximum area non-dimensionalized on the maximum beam and the one-half length between perpendiculars.

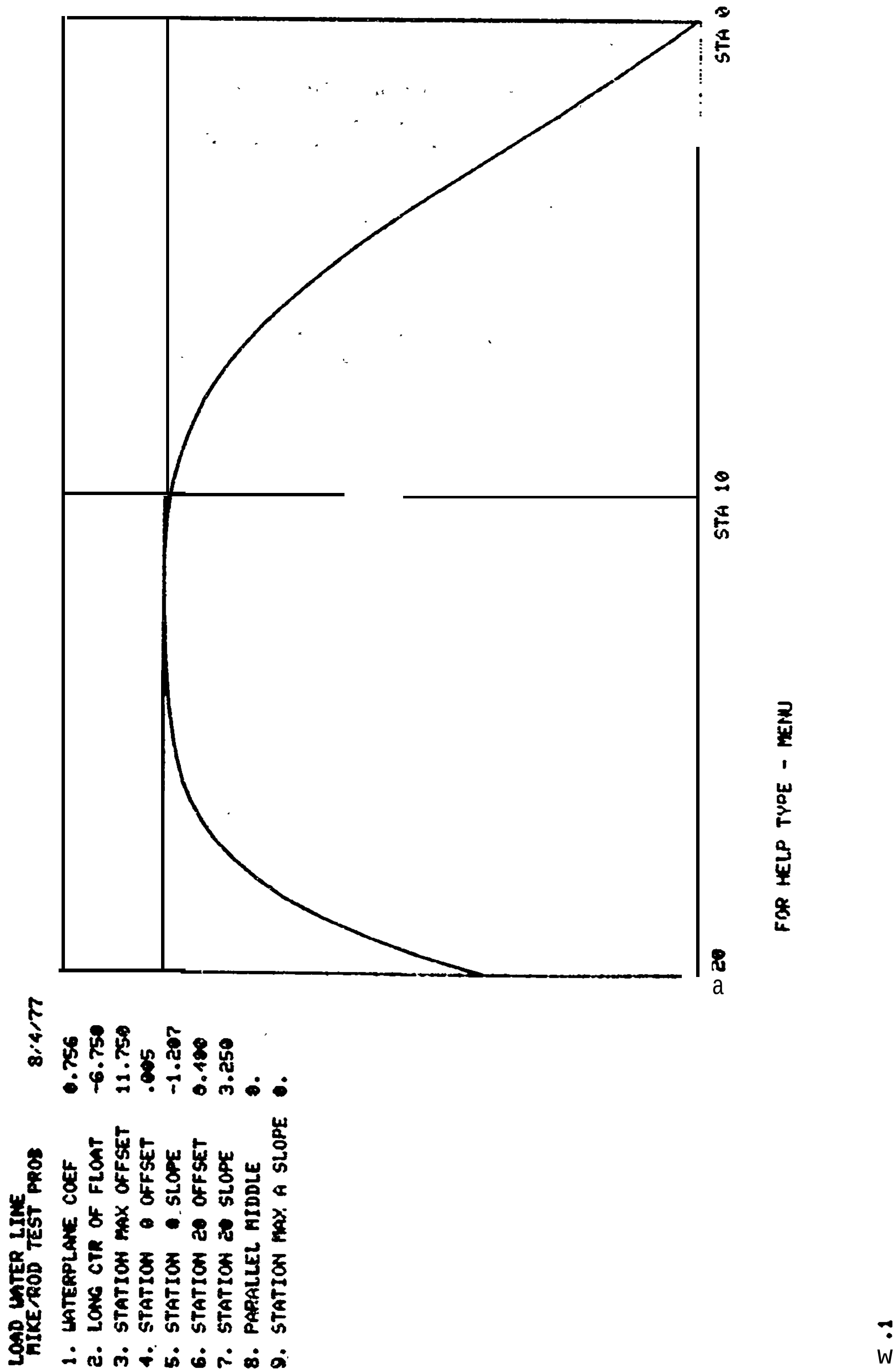


FIG. 3.6.2 LOAD WATER LINE FRAME WITH VALUES TYPED

Review Tensor WL - TDWL Frame

The user has available a sensitive method to “fine tune” small changes into the load waterline by using tensor vector mathematics. Experimentation is required to determine the limits on the parameter alterations allowable. Frame.

In this Mode the Following Additional Variables Appear:

10. TENSOR - STA O

This parameter expresses the amount of “pull” on the forward part of the curve at station O along a direction line specified by the station O slope.

11. TENSOR - END FWD SEGMT

This parameter expresses the amount of “push” on the forward part of the curve at the end of the forward segment along a direction line specified by the slope at the station of maximum area.

12. TENSOR - START AFT SEG

This parameter expresses the amount of “pull” on the after part of the curve at the forward end of the segment along a direction line specified by the slope at the station of maximum area.

13. TENSOR - STA 20

This parameter expresses the amount of “push” on the after part of the curve at the after end of the segment along a direction line specified by the slope at station 20.

3.7 DECK AT EDGE CURVE - EDGE FRAME

Review the non-dimensionalized deck at edge curve including the bow extension forward of station O. The current DWL curve is superimposed so the user can determine flare and tumble-home relations between the two curves.

Definitions for Frame - Deck at Edge Curve

1. STATION 20 OFFSET

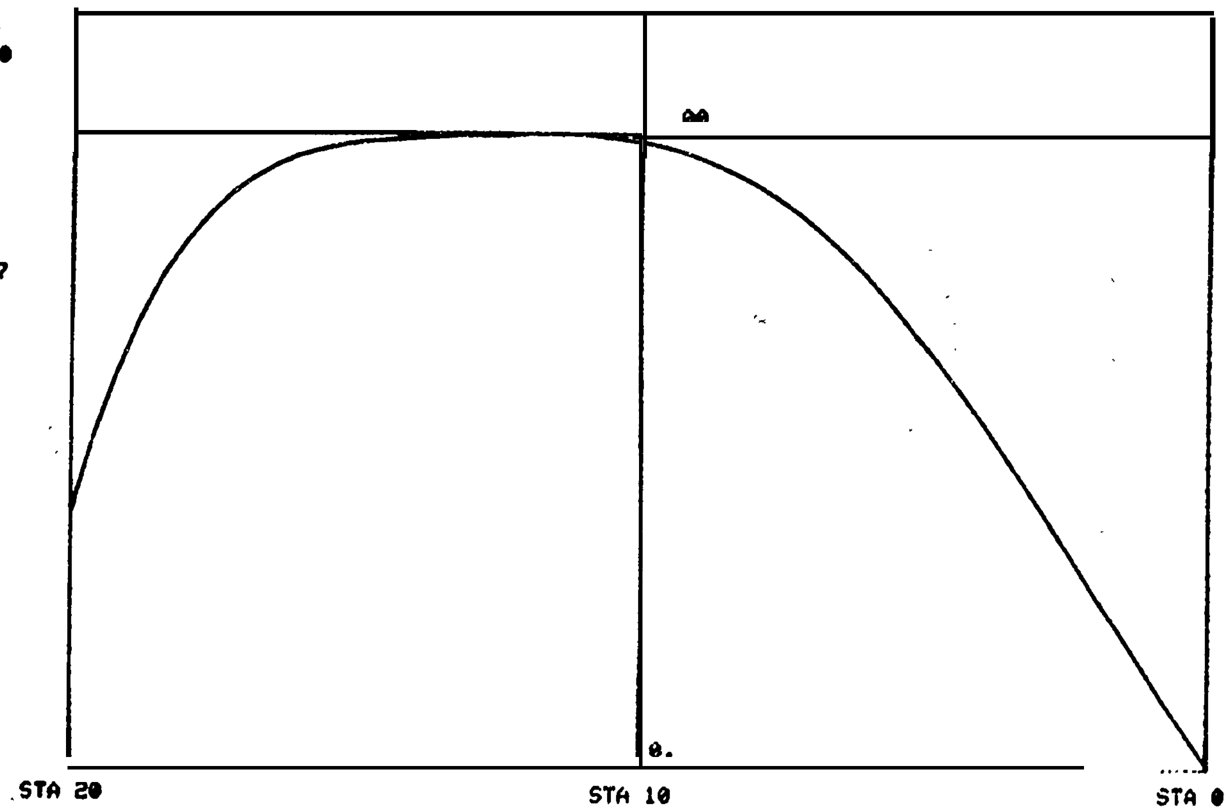
The offset of the deck curve at station 20 non-dimensionalized on the beam at station of maximum area.

2. STATION 20 SLOPE

The slope of the deck at edge curve at station 20 non-dimensionalized on the beam at station of maximum area and one-half length between perpendiculars.

TENSOR DWL CURVE
NEW HULL TEX RITTER

1. WATERPLANE COEF	0.756
2. LONG CTR OF FLOAT	-6.750
3. STATION 0 OFFSET	.005
4. STATION 20 OFFSET	0.400
5. TENSOR-STA 0	0.521
6. TENSOR-END FWD SEGMT	0.587
7. TENSOR-START AFT SEG	0.412
8. TENSOR-STA 20	1.015
9. STATION 0 SLOPE	-1.207
10.STATION 20 SLOPE	3.250
11.STATION MAX A SLOPE	0.



FOR HELP TYPE - MENU

FIG, 3.16

3. STATION 10 OFFSET

The offset of the deck at edge curve at station 10 non-dimensionalized on the beam at station of maximum area.

4. STATION 10 SLOPE

The slope of the deck at edge curve at station 10 non-dimensionalized on the beam at station of maximum area and one-half length between perpendiculars.

5. STATION O OFFSET

The offset of the deck at edge curve at station O non-dimensionalized on the beam at station of maximum area.

6. STATION O SLOPE

The slope of the deck at edge curve at station O non-dimensionalized on the beam at station of maximum area and one-half between perpendiculars.

7. PARALLEL MIDDLE

Length of optional flat portion on curve expressed as a fraction of the length between perpendiculars.

8. STATION AT PAR MIDDL

Longitudinal position of center of parallel middle expressed as a station location between O and 20.

9. BOW OVERHANG

Length of bow overhang forward of station O expressed as an absolute dimension, i.e., 20 feet, or as a fraction of the length between perpendiculars. A value less than 1.0 will be interpreted as a fraction of the length between perpendiculars. A value equal to or greater than 1.0 will be interpreted as an absolute value.

10• STERN OVERHANG

Length of stern overhang aft of station 20 expressed as an absolute dimension, i.e., 20 feet, or as a fraction of the length between perpendiculars. A value less than 1.0 will be interpreted as a fraction of the length between perpendiculars. A value equal to or greater than 1.0 will be interpreted as an absolute value.

11. TRANSOM RADIUS

Not Used.

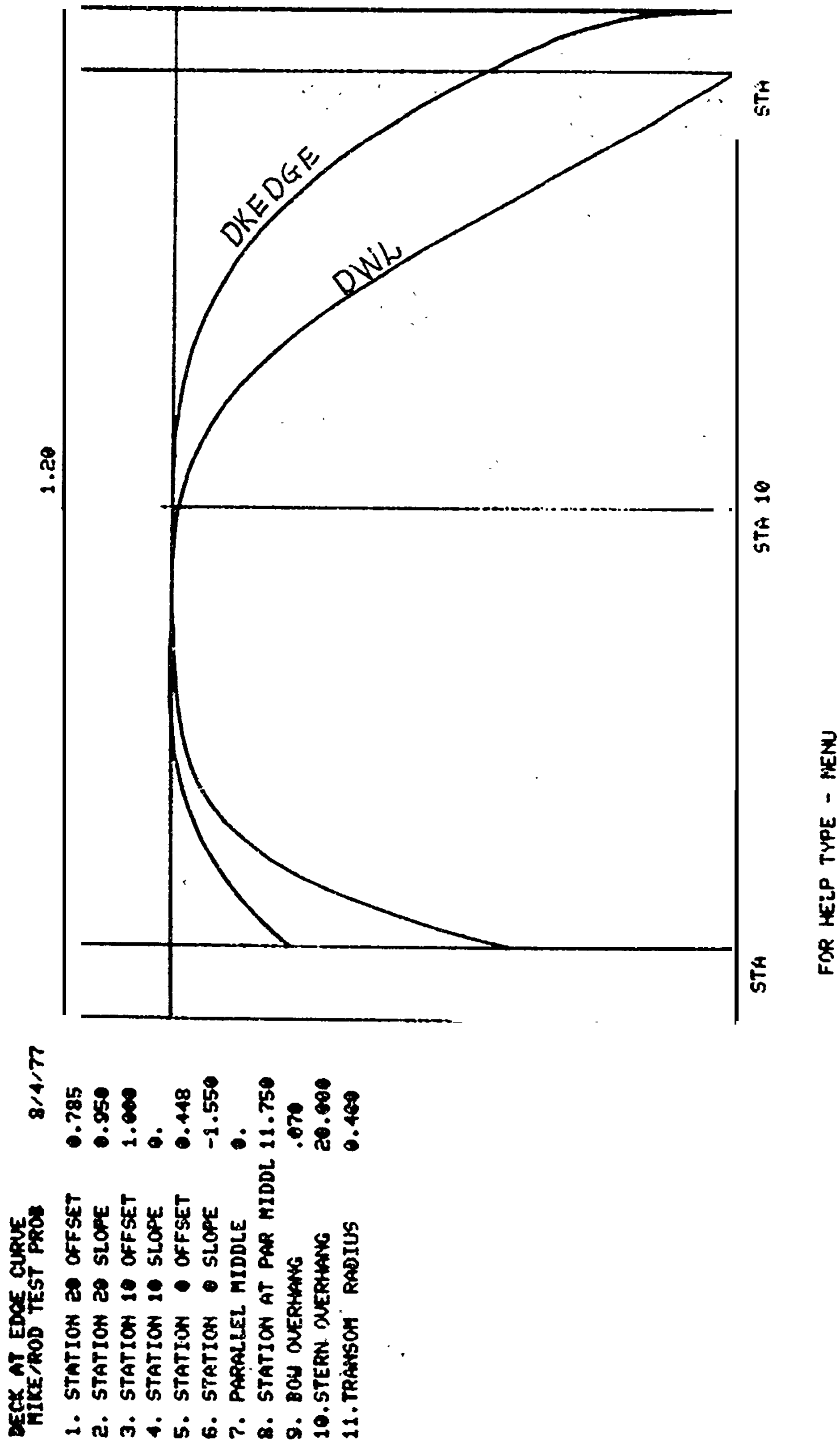


FIG. 3. 7.1 DECK AT EDGE CURVE FRAME

3.8 REVIEW PROFILE CURVE - PROF FRAME

Review inboard profile curve for hull form including sheer line, bow profile, keel rise curve, and stern profile.

Definitions for Frame - Inboard Profile

1. SECTION COEF STA-20

   The local section coefficient at station 20 defined as the area at station 20 divided by the local beam and the local draft.

2. STA OF KEEL RISE

   The longitudinal location of the beginning of the keel rise curve expressed as a station between station O and station 20.

3. BOW OVERHANG

   The length of the bow overhang forward of station O. This length is expressed as,either an absolute length or as a fraction of the length between perpendiculars.

4. DEPTH STA O

   The depth from the keel line to the sheer curve at station O expressed as an absolute dimension.

5. DEPTH STA 3

   The depth from the keel line to the sheer curve at station 3 expressed as an absolute dimension.

6. DEPTH STA io

   The depth from the keel line to the sheer curve at station 10 expressed as an absolute dimension.

7. DEPTH STA 20

   The depth from the keel line to the sheer line at station 20 expressed as an absolute dimension.

8. BOW ANGLE - DEGREES

   The angle of the bow profile as it crosses the DWL expressed in degrees. The user should be aware that the angle produced on display has been non-dimensionalized by draft and one-half length between perpendiculars.

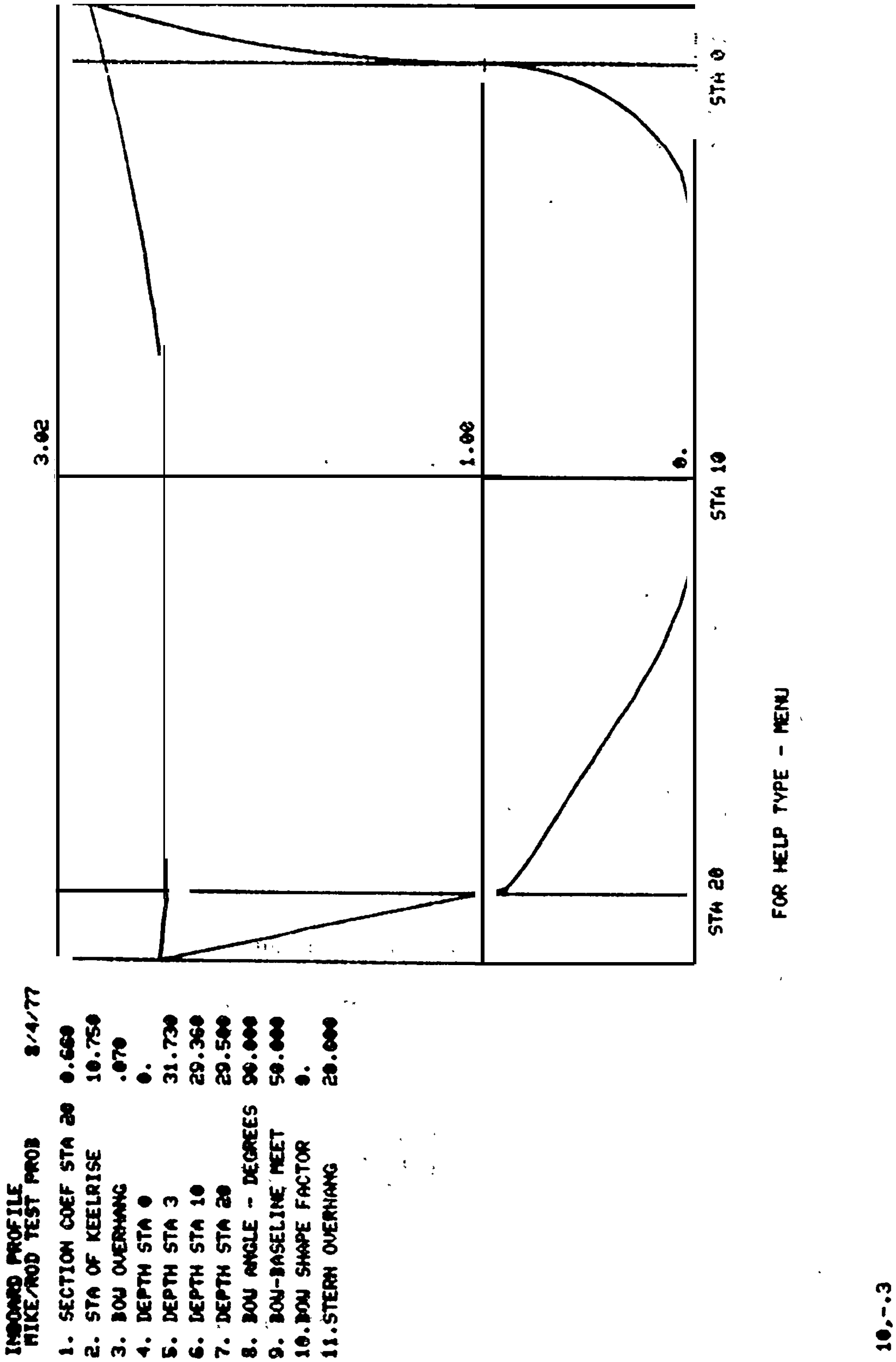


Fig. 3.8.1 INBOARD PROFILE FRAME

9. BOW-BASELINE MEET

The intersection of the bow profile and baseline. It is expressed either as an absolute dimension or as a fraction of the length between perpendiculars.

10. BOW SHAPE FACTOR

This variable affects the resulting shape of the bow profile below the DWL only. Experimentation is required to become acquainted with the effects possible. It is possible to produce bulbous bows and ice breaker type bows by altering this value.

11. STERN OVERHANG

The length of the stern overhang,aft of station 20 is expressed either as an absolute dimension or as a fraction of the length between perpendiculars.

3.9 REVIEW BOTTOM CURVE - FLAT FRAME

Display the half siding and optional flat of bottom curve. The DWL curve is superimposed for comparison.

Definitions of Frame - Flat of Bottom Curve

1. SLOPE-TRANS END

The slope at the intersection of the half siding and the after transition curve. The transition curve connects the midship portion and the half siding curve.

2. STA-START MIDSHIP-

The longitudinal location of the beginning of the midship portion of the flat of bottom curve. The midship portion is defined as the portion of the flat of bottom curve defined exclusively by the radius of the bilge necessary to get a required section area.

3.

The longitudinal location of the end of the midship portion of the flat of bottom curve. The midship portion is defined as the portion of the flat of bottom curve defined exclusively by the radius of the bilge necessary to get a required section area.

4. STA-START TRANSITION

The longitudinal location of the beginning of the transition curve as it leaves the half siding to meet the midship portion of the flat of bottom curve.

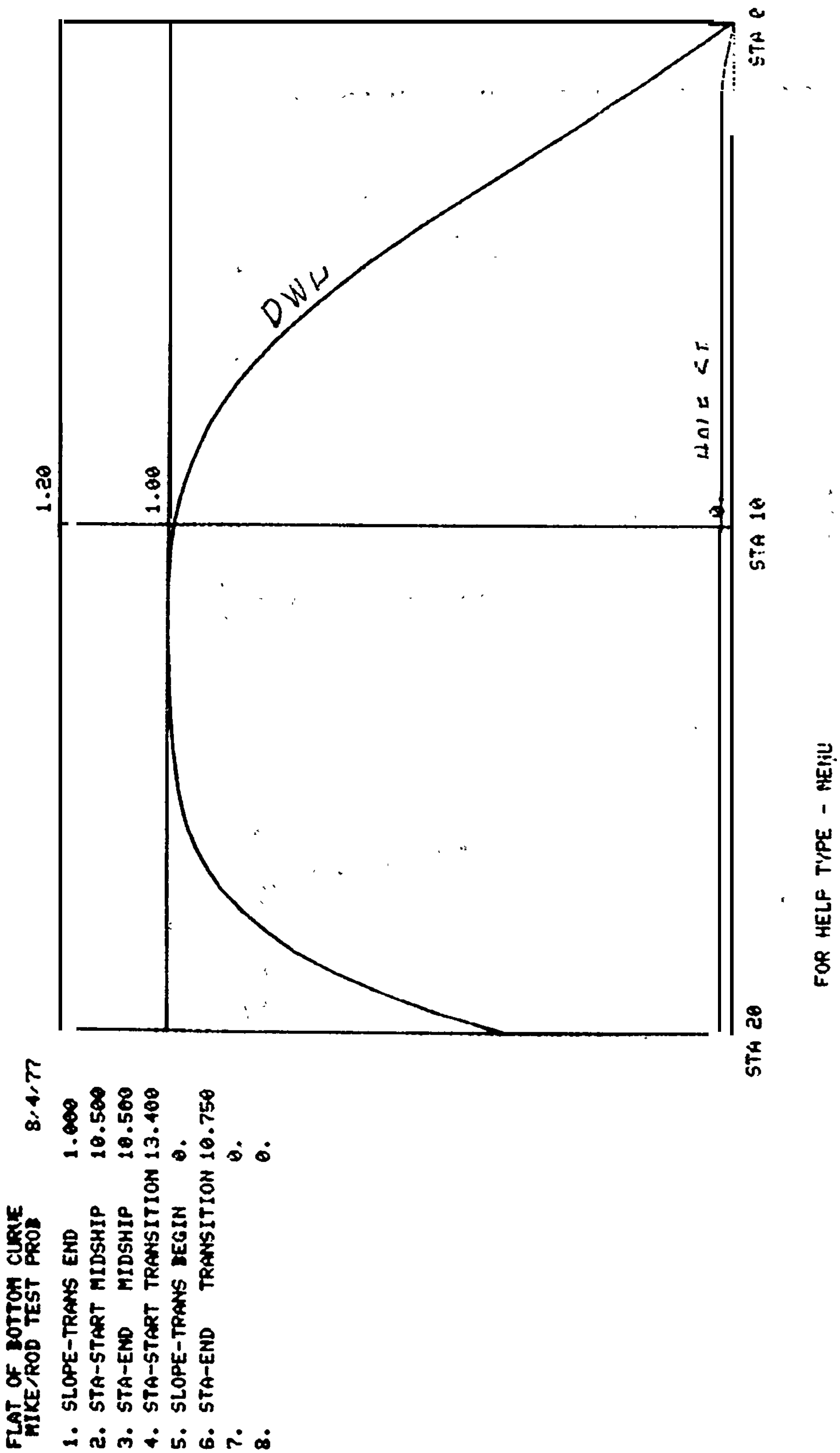
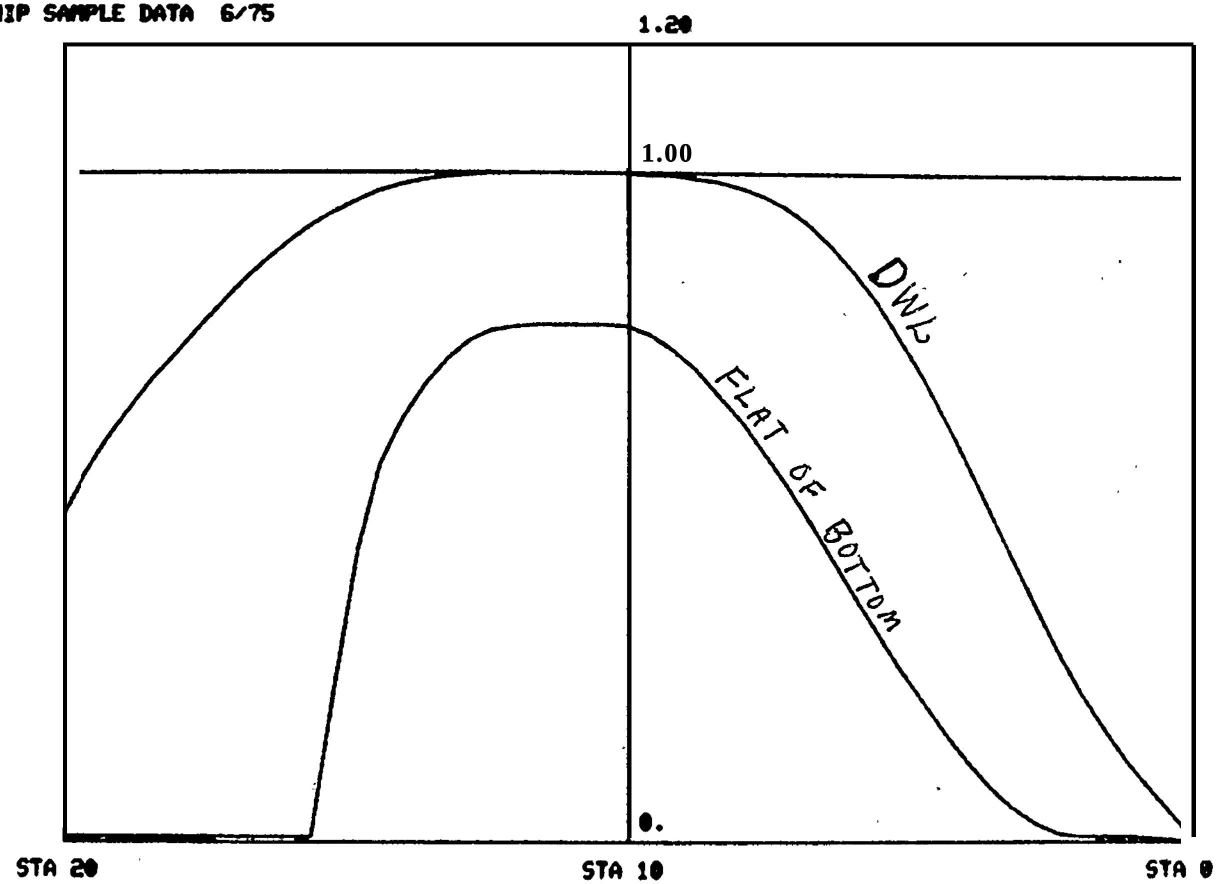


FIG. 3.9. I FLAT OF BOTTOM CURVE FRAME

FLAT OF BOTTOM CURVE
HULLGEN2 AIRCRAFT CARRIER SHIP SAMPLE DATA 6/75

i.	SLOPE-TRANS END	8.000
2.	STA-START MIDSHIP	10.250
3.	STA-ENO MIDSHIP	14.250
4.	STA-START TRANSITION	2.000
5.	SLOPE-TRANS BEGIN	0.
6.	STA-END TRANSITION	15.500
7.		0.
8.		0.



FOR HELP TYPE - MENU

5. SLOPE-TRANS BEGIN

The slope of the transition curve at the point where it intersects with the half siding forward of the midship portion of the flat of bottom curve.

6. STA-END TRANSITION

The longitudinal location of the end of the transition curve as it leaves the midship portion and intersects with the half siding.

7. NOT USED

8. NOT USED

3.10 REVIEW SLOPES - DWL - SWSLP FRAME

Review the longitudinal distribution of section slopes at the design waterline. The slopes are plotted in degrees. O degrees corresponds to a zero slope and 90 degrees corresponds to a vertical slope, i.e., infinite slope.

Definitions for Frame - Slopes at DWL

1. STATION O ORDINATE

Ordinate of slope curve at station O. The units are degrees form O to 180.

2. STATION O SLOPE .

The slope of the slope curve at station O. Non-dimensionalized on one-half length between perpendiculars.

3. STATION 10 ORDINATE

Ordinate of slope curve at station 10. The units are degrees from O to 180.

4. STATION 10 SLOPE

The slope of the slope curve at station 10. Non-dimensionalized on one-half length between perpendiculars.

5. STATION 20 ORDINATE

Ordinate of slope at station 20. The units are degrees from O to 180.

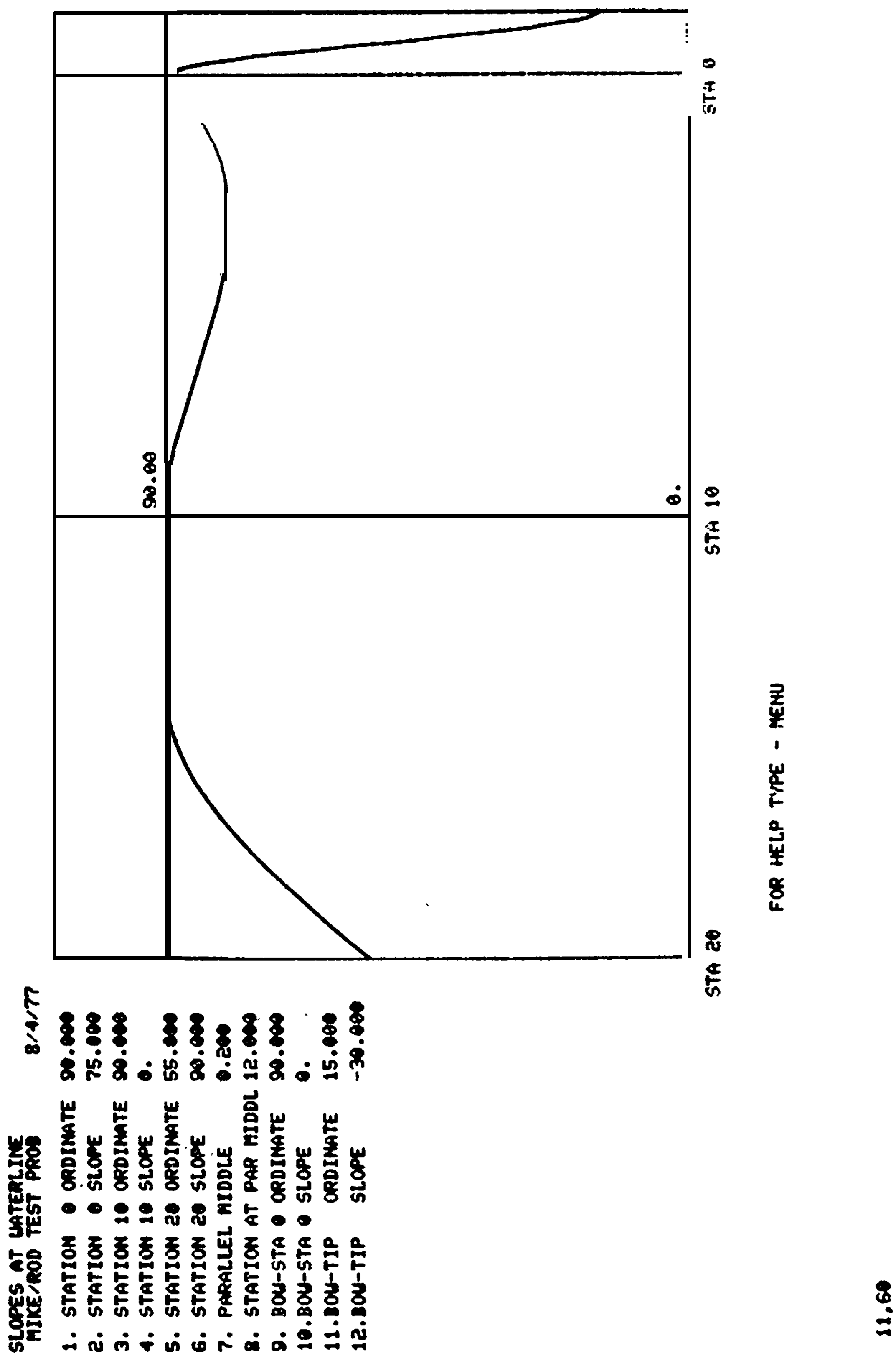


FIG. 3.10.2 SLOPES AT WATERLINE FRAME WITH VALUES TYPED

6. STATION 20 SLOPE

The slope of the slope curve at station 20. Non-dimensionalized on one-half length between prependiculars.

7. PARALLEL MIDDLE

Length of optional flat spot separating the forward and after segments of the slope curve. This parameter-is expressed as a fraction of the length between perpendiculars.

8. STATION OF PAR MIDDL

Longitudinal location of the connection of the forward and after curve segment. This also becomes the center of the parallel middle if specified. This location is expressed as a station location between 0 and 20.

9. BOW-STA 0 ORDINATE

The ordinate for the bow portion slope curve forward of station O at station 0. The units are degrees.

10. BOW-STA 0 SLOPE

The slope of the slope curve at station O for the bow portion of the curve. This parameter is expressed as non-dimensionalized on one-half length between perpendiculars.

11. BOW TIP-ORDINATE

The ordinate for the bow portion slope curve forward of station O at the bow tip. The units are degrees.

12. BOW TIP-SLOPE

The slope of the slope curve at station 0 for the bow-portion of the curve. This parameter is expressed as non-dimensionalized on one-half length between the perpendiculars.

3.11 REVIEW SLOPES - DEADRS- SDSLP FRAME

Review the longitudinal distribution of section slopes at the baseline. The slopes are plotted in degrees. 0 degrees corresponds to a zero slope and 90 degrees corresponds to a vertical slope, i.e., infinite slope.

Definitions for Frame - Slopes at DEADRS

1. STATION 0 ORDINATE

Ordinate of slope,curve at station 0. The units are degrees from 0 to 180.

2. STATION 0 SLOPE

The slope of the slope curve at station 0. Non-dimensionalized on one-half length between perpendiculars.

3. STATION 10 ORDINATE

Ordinate of slope curve at station 10. The units are degrees from 0 to 180.

4. STATION 10 SLOPE

The slope of the slope curve at station 10. Non-dimensionalized on one-half length between perpendiculars.

5. STATION 20 ORDINATE

Ordinate of slope curve at station 20. The units are degrees from O to 180.

6. STATION 20 SLOPE

The slope of the .slope curve at station 20. Non-dimensionalized on one-half length between perpendiculars.

7. PARALLEL MIDDLE

Length of optional flat spot separating the forward and after segments of the slope curve. This parameter is expressed as a fraction of the length between perpendiculars.

8. STATION OF PAR MIDDL

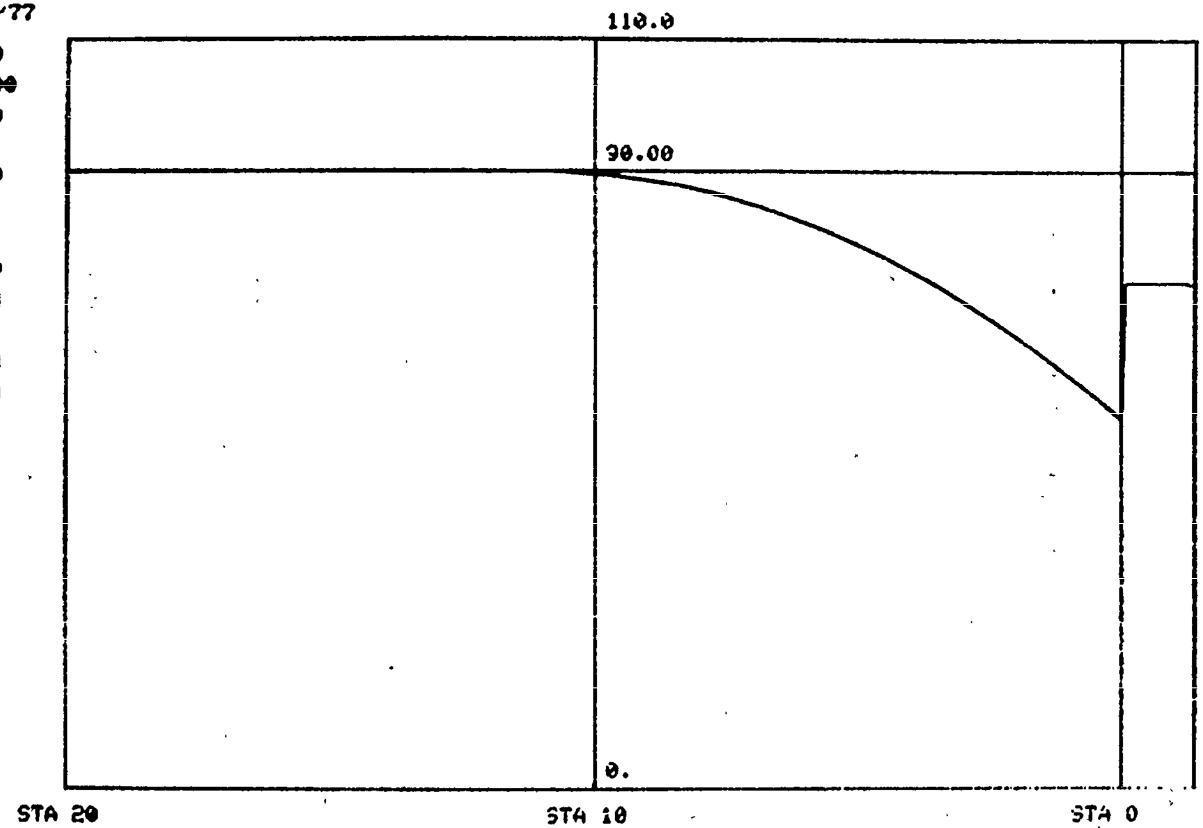
Longitudinal location of the connection of the forward and the after curve segment. This also becomes the center of the parallel middle if specified. This location. is expressed as a station location between 0 and 20.

3.12 REVIEW SLOPES DK EDGE SESLP FRAME

Review the longitudinal distribution of section slopes at the deck edge. The slopes are plotted in degrees. 0 degrees corresponds to a zero slope and 90 degrees corresponds to a vertical slope, i.e., infinite slope.

SLOPES AT DECK EDGE
MIKE/ROD TEST PROB 8/4/77

1. STATION 0 ORDINATE 54.000
2. STATION 0 SLOPE -65.000
3. STATION 10 ORDINATE 90.000
4. STATION 10 SLOPE 0.
5. STATION 20 ORDINATE 90.000
6. STATION 20 SLOPE 0.
7. PARALLEL MIDDLE .100
8. STATION AT PAR MIDDL 12.000
9. BOW-STA 0 ORDINATE 73.453
10. BOW-STA 0 SLOPE 8.179
11. BOW-TIP ORDINATE 73.453
12. BOW-TIP SLOPE -8.179



FOR HELP TYPE - MENU

FIG. 3.12.1 SLOPES AT DECK EDGE FRAME

Definitions for Frame - Slopes at DKEDGE

1. STATION 0 ORDINATE”

   Ordinate of slope curve at station O. The units are degrees from 0 to 180.

2. STATION 0 SLOPE

   The slope of the slope curve at station O. Non-dimensionalized on one-half length between perpendiculars.

3. STATION 10 ORDINATE

   Ordinate of slope curve at station 10. The units are degrees from 0 to 180.

4. STATION 10 SLOPE

   The slope of the slope curve at station 10. Non-dimensionalized on one-half length between perpendiculars.

5. STATION 20 ORDINATE

   Ordinate of slope curve at station 20. The units are degrees from 0 to 180.

6. STATION 20 SLOPE

   The slope of the slope curve at station 20. Non-dimensionalized on one-half length between prependiculars.

7. PARALLEL MIDDLE

   Length of optional flat spot separating the forward and after segments of the slope curve. 'This parameter is expressed as a fraction of the length between perpendiculars.

8. STATION OF PAR MIDDL

   Longitudinal location of the connection of the forward and after curve segment. This also becomes the center of the parallel middle if specified. This location is expressed as a station location between 0 and 20.

9. BOW-STA 0 ORDINATE

   The ordinate for the bow portion slope curve forward of station 0 at station 0. The units are degrees.

10• BOW-STA 0 SLOPE

The slope of the slope curve at station O for the bow portion of the curve. This parameter is expressed as non-dimensionalized on one-half length between perpendiculars.

11. BOW TIP-ORDINATE

The ordinate for the bow portion slope curve forward of station 0 at the bow tip. The units are degrees.

12. BOW TIP-SLOPE

The slope of the slope curve at station O for the bow portion of the curve. This parameter is ‘expressed as non-dimensionalized on one-half length between prependiculars.

3.13 REVIEW BODY PLAN - BODY FRAME

This frame shows the body plan that results from the characteristics of all the curves presented hereto.

Definitions for Frame - Body Plan

1. POINTS BELOW DWL

The number of points used to depict the body plan below the DWL. The minimum number of points' is 3. The-default is 16 points. There is no maximum number of points. The program has a limit, however, on the total number of offsets. This limit is 812.

2. POINTS ABOVE DWL

The number of points used to depict the body plan above the DWL. The minimum number of points is 3. The default is 13 points. There is no maximum number of points. The program has limit, however, on the total number of offsets. This limit is 812.

3. PT DISTRIBUTION BELOW DWL

This parameter determines the distribution of points below, the DWL. A value of 1.0 creates a linear distribution of points. A value greater than 1.0 puts points closer together at the lower end of the curve, near the baseline. A value less than 1.0 but greater than 0.0 puts points closer together at the upper end of ;the curve, near the baseline. The default is 3.0 thereby placing ’points closer together near the baseline.

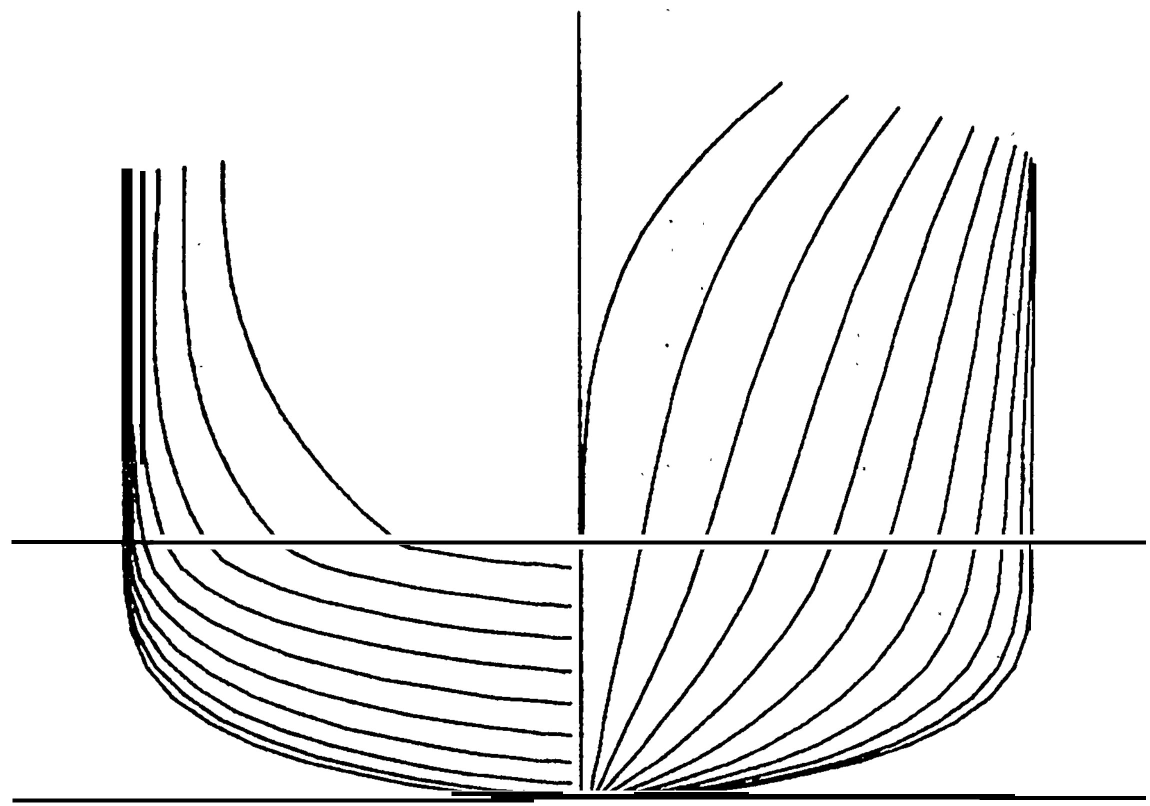
4. PT DISTRIB ABOVE DWL

This parameter determines the distribution of points above the DWL. A value of 1.0 creates a linear distribution of points. A value

FIG. 3.13.1 800Y PLAN FRAME

BODY PLAN

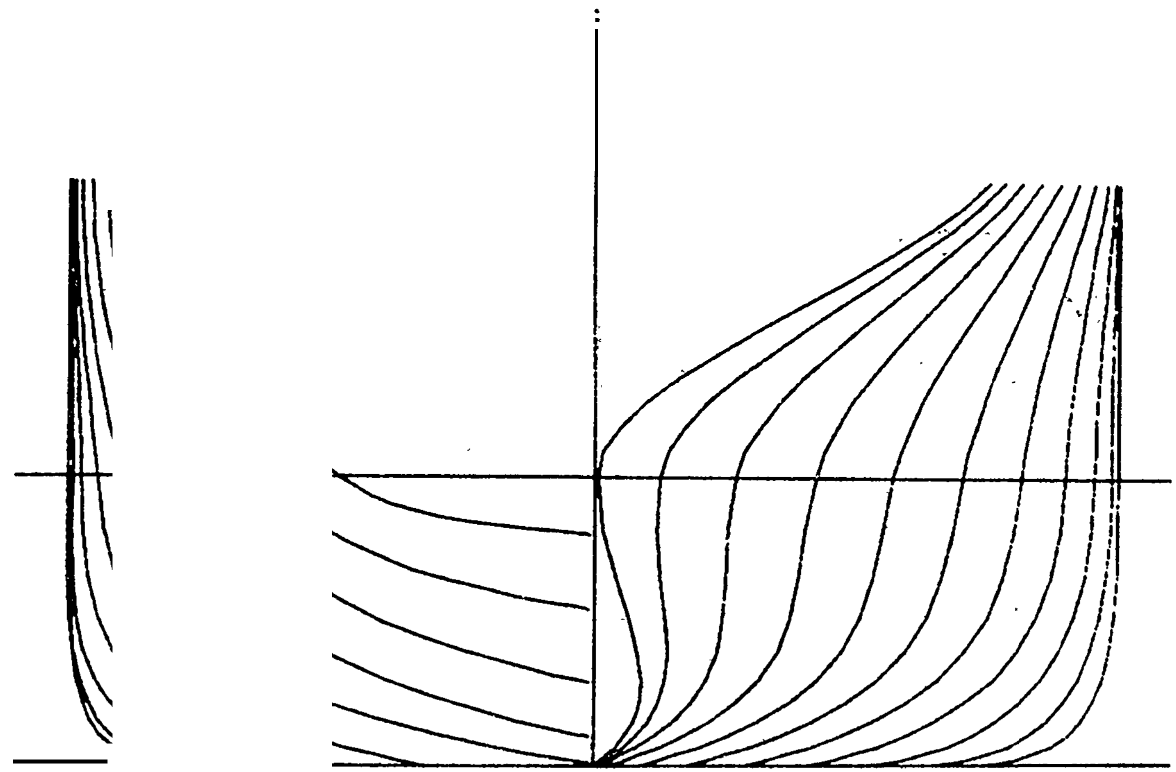
1.	POINTS BELOW DWL	16.000
2.	POINTS ABOVE DWL	13.000
3.	PT DISTRIB BELOW DWL	3.000
4.	PT DISTRIB ABOVE DWL	1.000
5.	STATIONS	0.
6.		1.000
7.		2.000
8.		3.000
9.		4.000
10.		5.000
11.		6.000
12.		7.000
13.		8.000
14.		9.000
15.		10.000
16.		11.000
17.		12.000
18.		13.000
19.		14.000
20.		15.000
21.		16.000
22.		17.000
23.		18.000
24.		19.000
25.		20.000
26.		99.000
27.		99.000



FOR HELP TYPE - MENU

BODY PLAN
HULLGEN2 AIRCRAFT CARRIER SHIP SAMPLE DATA 6/75

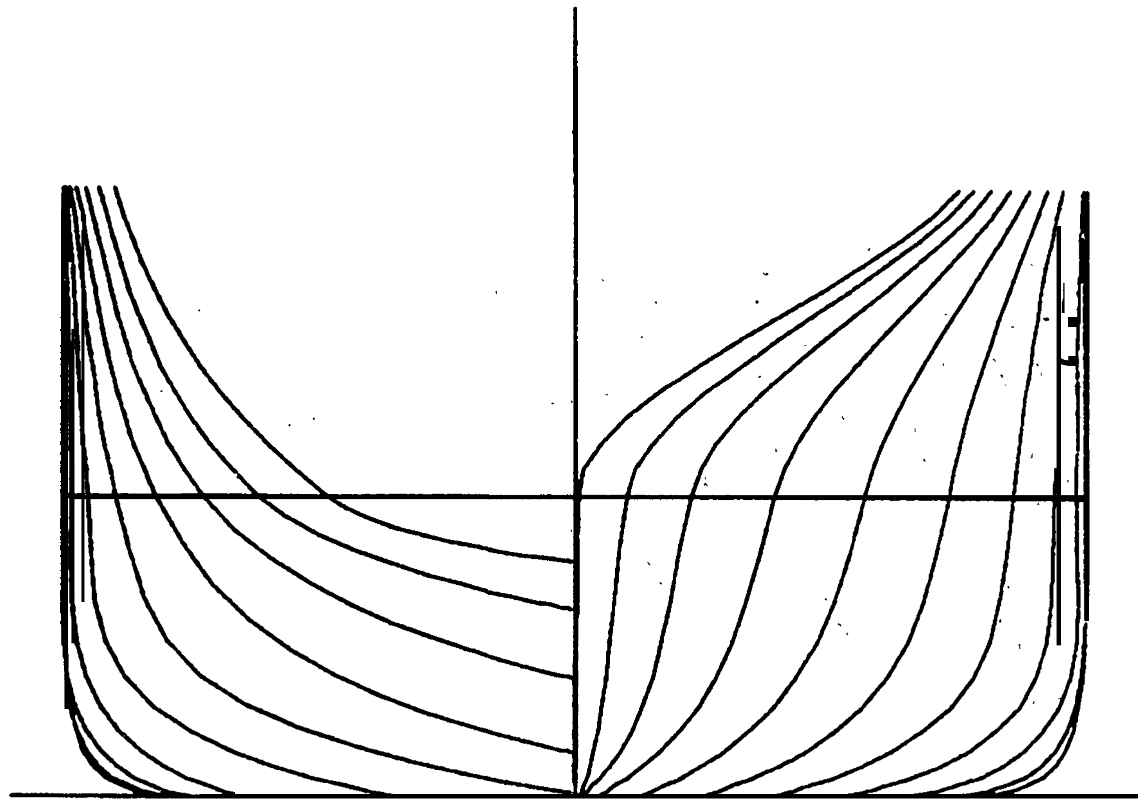
1.	POINTS BELOW DWL	16.000
2.	POINTS ABOVE DWL	13.000
3.	PT DISTRIB BELOW DWL	3.000
4.	PT DISTRIB ABOVE DWL	1.000
5.	STATIONS	0.
6.		1.000
7.		2.000
8.		3.000
9.		4.000
10.		5.000
11.		6.000
12.		7.000
13.		8.000
14.		9.000
15.		10.000
16.		11.000
17.		12.000
18.		13.000
19.		14.000
20.		15.000
21.		16.000
22.		17.000
23.		18.000
24.		19.000
25.		20.000
26.		99.000
27.		99.000



FOR HELP TYPE - MENU

BODY PLAN
HULLGEN2 AIRCRAFT CARRIER SHIP SAMPLE DATA 6/75

1.	POINTS BELOW DWL	16.000
2.	POINTS ABOVE DWL	13.000
3.	PT DISTRIB BELOW DWL	3.000
4.	PT DISTRIB ABOVE DWL	1.000
5.	STATIONS	0.
6.		1.000
7.		2.000
8.		3.000
9.		4.000
10.		5.000
11.		6.000
12.		7.000
13.		8.000
14.		9.000
15.		10.000
16.		11.000
17.		12.000
18.		13.000
19.		14.000
20.		15.000
21.		16.000
22.		17.000
23.		18.000
24.		19.000
25.		20.000
26.		99.000
27.		99.000

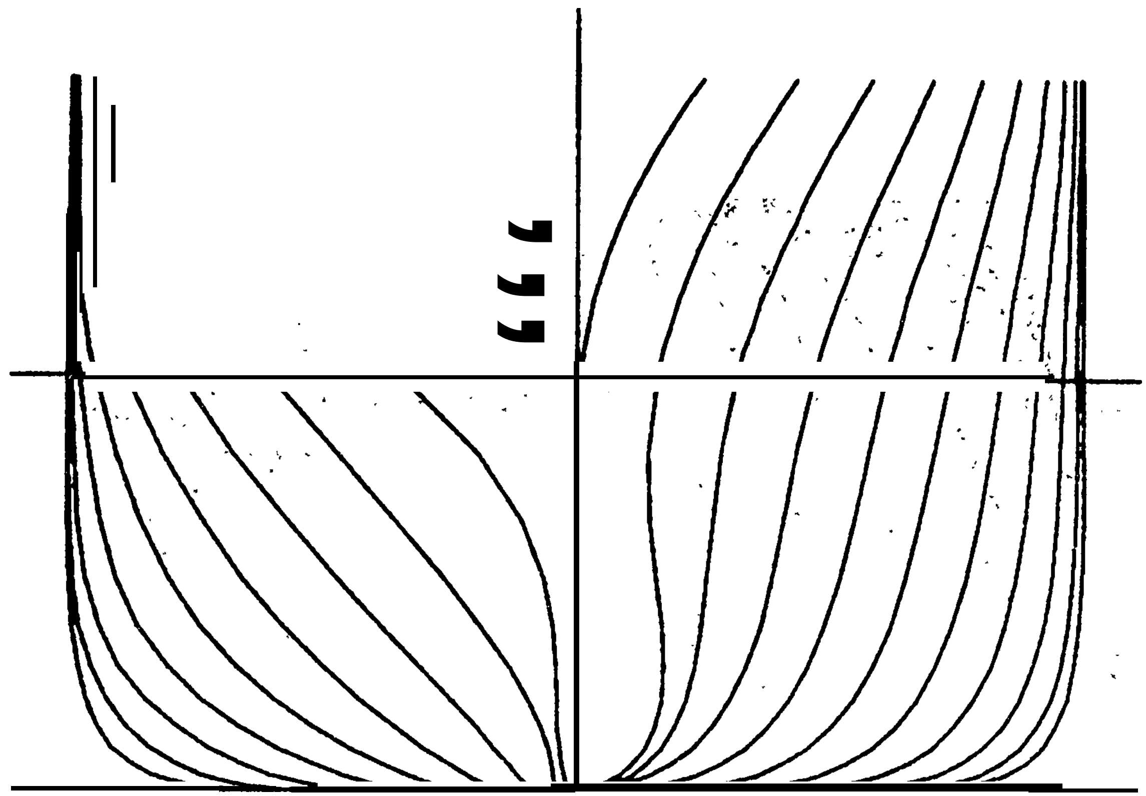


FOR HELP TYPE MENU

BODY PLAN

1.	POINTS BELOW DWL	16.000
2.	POINTS ABOVE DWL	13.000
3.	PT DISTRIB BELOW DWL	3.000
4.	PT DISTRIB ABOVE DWL	1.000
5.	STATIONS	0.
6.		1.000
7.		2.000
8.		3.000
9.		4.000
10.		5.000
11.		6.000
12.		7.000
13.		8.000
14.		9.000
15.		10.000
16.		11.000
17.		12.000
18.		13.000
19.		14.000
20.		15.000
21.		16.000
22.		17.000
23.		18.000
24.		19.000
25.		20.000
26.		99.000
27.		99.000

77?READ DCX

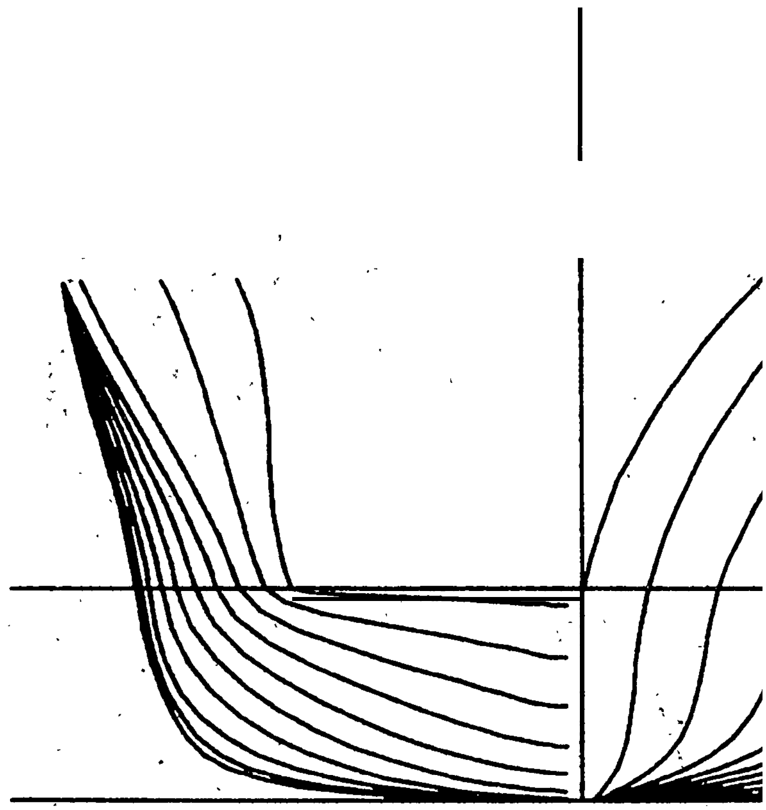


FOR HELP TYPE - MENU

DATA.

DODY PLAN

1. POINTS DELOW DUL 16.000
2. POINTS ABOVE DUL 13.000
3. PT DISTRID BELOW DUL BELOW DUL 3.000
4. PT DISTRIB ABOVE DUL WOVE DUL 1.000
5. STATIONS 0 .
6. 1.000
7. 2.000
8. 3.000
9. 4.000
10. 5.000
11. 6.000
12. 7.000
13. 8.000
14. 9.000
15. 10.000
16. 11.000
17. 12000
18. 13.000
19. 14.000
20. 15.000
21. 16.000
22. 17.000
23. 18.000
24. 19.000
25. 20.000
26. 99.000
27.

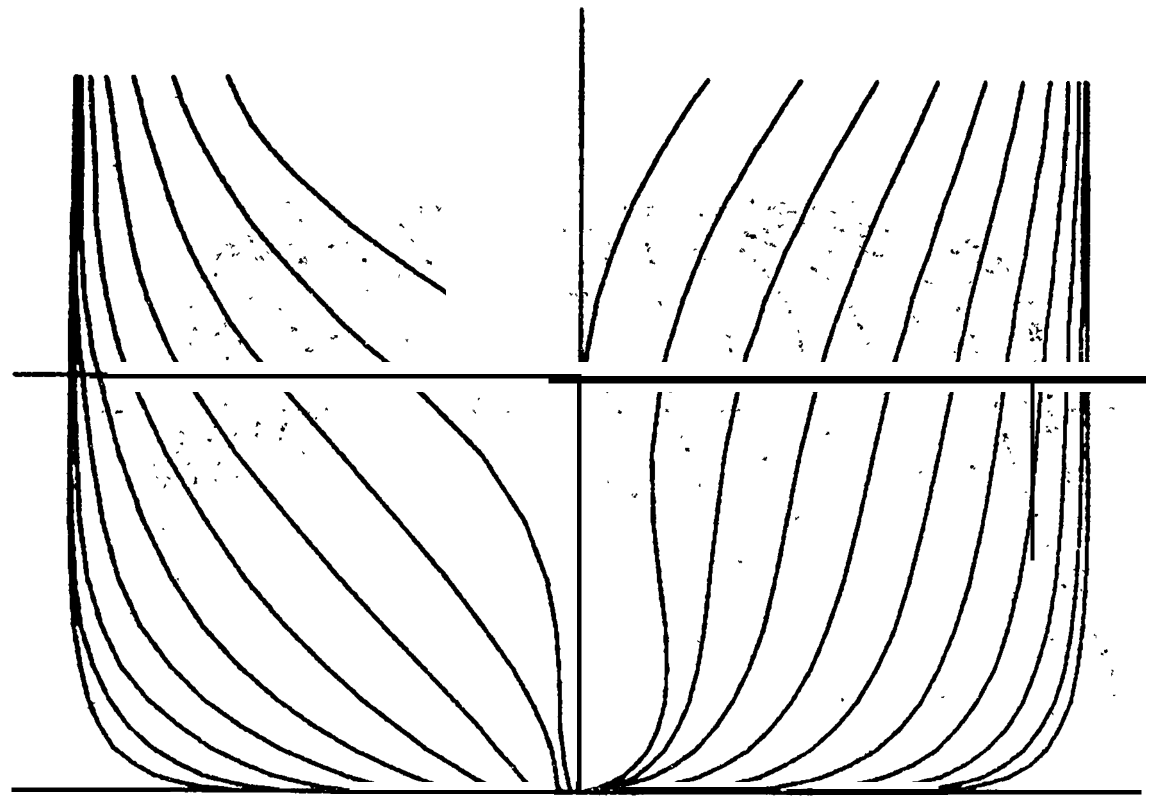


FOR HELP TYPE - MENU

BODY PLAN

??READ DC*

1.	POINTS BELOW DWL	16.000
2.	POINTS ABOVE DWL	13.000
3.	PT DISTRIB BELOW DWL	3.000
4.	PT DISTRIB ABOVE DWL	1.000
5.	STATIONS	0.
6.		1.000
7.		2.000
8.		3.000
9.		4.000
10.		5.000
11.		6.000
12.		7.000
13.		8.000
14.		9.000
15.		10.000
16.		11.000
17.		12.000
18.		13.000
19.		14.000
20.		15.000
21.		16.000
22.		17.000
23.		18.000
24.		19.000
25.		20.000
26.		99.000
27.		99.000



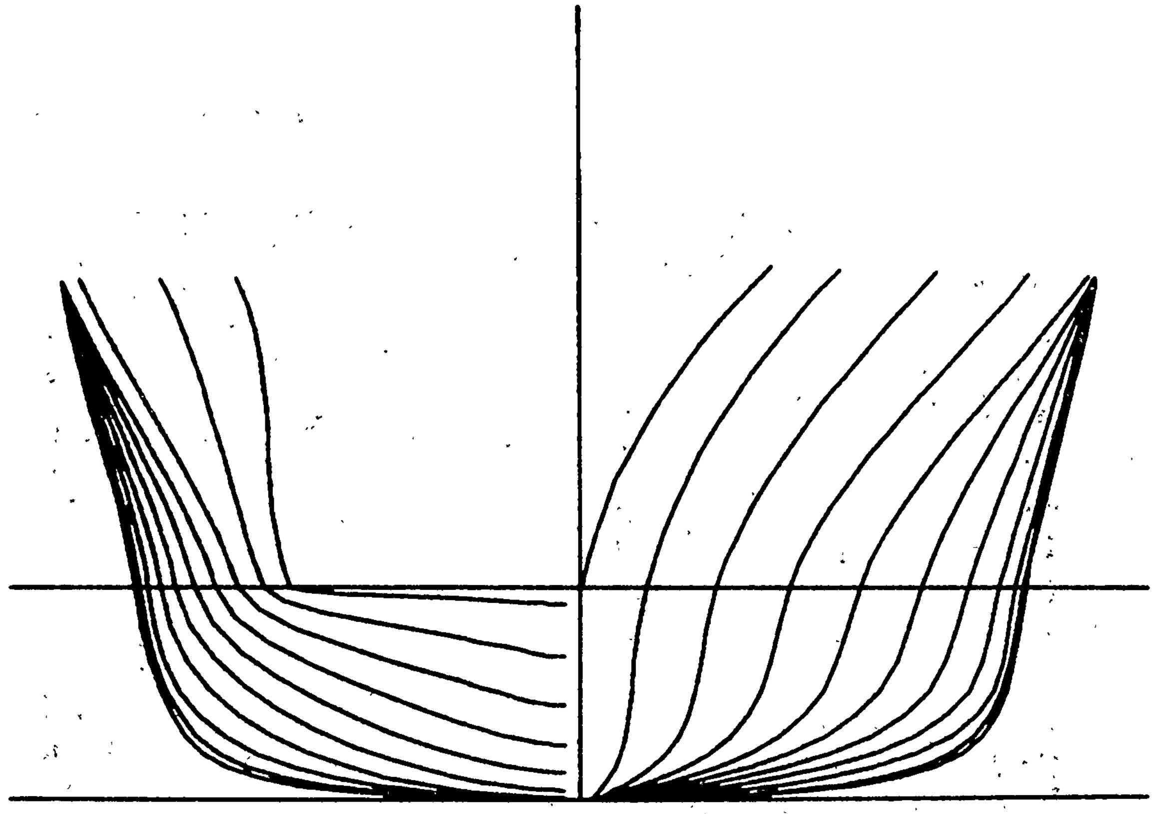
FOR HELP TYPE - MENU

DATA.

BODY PLAN

1.	POINTS BELOW DWL	16.000
2.	POINTS ABOVE DWL	13.000
3.	PT DISTRIB BELOW DWL	3.000
4.	PT DISTRIB ABOVE DWL	1.000
5.	STATIONS	0.
6.		1.000
7.		2.000
8.		3.000
9.		4.000
10.		5.000
11.		6.000
12.		7.000
13.		8.000
14.		9.000
15.		10.000
16.		11.000
17.		12.000
18.		13.000
19.		14.000
20.		15.000
21.		16.000
22.		17.000
23.		18.000
24.		19.000
25.		20.000
26.		99.000
27.		99.000

AF



FOR HELP TYPE - MENU

greater than 1.0 puts points closer together at the lower end of the curve, near the deck at edge. A value less than 1.0 but greater than 0.0 puts points closer together at the upper end of the curve, near the DWL. The default is 1.0 for a linear distribution of points.

5. TO 33. STATIONS

The longitudinal locations of sections expressed as a station location from O to 20. The values are not limited to integer values. Negative stations, i.e., forward of station O are-acceptable. Stations aft of station 20 are not allowed in this version of the program. Any number of stations up to a maximum of 28 are allowed. A 99.000 indicates that at least one additional station location is available to the user.

3.14 REVIEW OUTPUT OPTIONS - OUT FRAME

The USEF has several options available as to the distribution and types of output he wishes to generate.

The outputs requested are produced only upon exit from the program. This means that only one body plan can be created per each running of the program. The ease with which the program can be re-executed directly from the terminal makes this a minor inconvenience.

Definitions for Frame - Review Output Options

1. PLOT BODY PLAN

Setting this option to 1.0 will produce a scaled CALCOMP plot upon termination of the program. The scale for the plot can be set by setting the plot scale (identification number 14.) to desired value.

2. PUNCH OFFSETS

Punched offsets can be created upon the termination of the program. These offsets are compatible with other naval architecture programs such as SHPC and SAP.

3. PRINT OFFSETS

The offsets can be printed if desired.

4. PUNCH BND COND 1 + 2

The boundary condition values can be punched on cards for some future execution of the program.

5. PRINT BND COND 1 + 2

The boundary condition. values can be printed, if desired.

6. PRINT SA + DWI INFO

Detailed information on the section area curve and--load waterline curve can be printed if desired.

7. PRINT HYDROSTATICS

Very basic hydrostatics regarding stability. and centers of bouyancy at the design condition can be printed out.

8. NOT USED '

9. PRINT MIT SEAKEEPING

Data for the MIT eakeeping program can be created and printed out. Warning....be very careful with this output. The coding assumes the old version of the program with 20 stations and 29 points per station. The program may be required to run as the old version to produce valid results.

10. PUNCH MIT SEAKEEPING

Data for the MIT seakeeping program can be created and punched out in a format for direct input. Please check warning in Item No. 9 above about possible restrictions to valid results.

11. PRINT YFL7 SEAKEEPING

Data for the YF17 seakeeping, program can be created and printed out. Please check the warning in Item No. 9 above about possible restrictions to valid results.

12. PUNCH YF17 SEAKEEPING

Data for the YF17 seakeeping program can be created and punched out in a format for direct input. Please check warning in Item No. 9 above about possible restrictions to valid results.

13. ADD SHIP TO INPUT

This is a new option designed to make it possible to extend the input data file without resorting to punched cards. Setting this option creates a new file of input data consisting of the old data plus the boundary conditions for the current body plan. This file has the temporary file name NEWDA. The cataloged procedure saves this file for future use by cataloging it onto permanent file space.

```
REVIEW OUTPUT OPTNS
 MIKE/ROD TEST PROB         8/4/77

1. PLOT BODY PLAN        0.
2. PUNCH OFFSETS         0.
3. PRINT OFFSETS         0.
4. PUNCH BND COND 1+2    0.
5. PRINT BND COND 1+2    0.
6. PRINT SA +DWL INFO    1.000
7. PRINT HYDROSTATICS    0.
8. NOT USED              0.
9. PRINT MIT SEAKEEPING  0.
10.PUNCH MIT SEAKEEPING  0.
11.PRINT YF17 SEAKEEPNG  0.
12.PUNCH YF17 SEAKEEPNG  0.
13.ADD SHIP TO INPUT     0.
14.PLOT SCALE IN/FT      .100

                                        FOR HELP TYPE - MENU

 1,1,3,1,7,1
1,1,3,1,7,1
```

F13. 30.14.1 REVIEW OUTPUT OPTIONS

```
REVIEW OUTPUT OPTNS
 MIKE/ROD TEST PROB         8/4/77

1. PLOT BODY PLAN        1.000
2. PUNCH OFFSETS         0.
3. PRINT OFFSETS         1.000
4. PUNCH BND COND 1+2    0.
5. PRINT BND COND 1+2    0.
6. PRINT SA +DWL INFO    1.000
7. PRINT HYDROSTATICS    1.000
8. NOT USED              0.
9. PRINT MIT SEAKEEPING  0.
10.PUNCH MIT SEAKEEPING  0.
11.PRINT YF17 SEAKEEPNG  0.
12.PUNCH YF17 SEAKEEPNG  0.
13.ADD SHIP TO INPUT     0.
14.PLOT SCALE IN/FT      .100

                                        FOR HELF
```

FIG. 3.14.2 REVIEW OUTPUT OPTIONS WITH RESULTS

14. PLOT SCALE IN/FT

Set the scale for CALCOMP plots if Item 1. is set above. The default is .100 inches/foot. Note - the ship is non-dimensional internal to the program, therefore the scale could be considered as inches/meter, inches/yards, etc.

3.17 PROGRAM STOP - STOP

The stop option ends execution of the program. Prior to the actual end of the program, any output options that have beep requested by the user are carried out. The data for the hull created just prior to the stop command is used for the outputs requested. This includes the addition of data to the input data file if requested by the user.

3.18 RESTORE OLD CURVE - OLD

Typing old in any frame reproduces the data and curve as it existed upon entering the frame.

This means that if more than one change is made within the frame, the values of the data for restoration are those that existed upon entering the frame.

3.19 CHANGE TITLE - TITLE

To change the title at any time - Type title and the new title desired.

Examples: Title - THE NEW HULL 17 APRIL 1978
Title - VERSION NO. 2 RUN NO. 25

5.1 PLANS FOR FUTURE IMPROVEMENTS

This section lists the suggestions for additions or improvements that are considered feasible for this program. The order of presentation does not necessarily indicate any particular priority for implementation.

The user with a hot idea should scan this list to see if his idea is already on the list. If it is not, call F, R. Bjorklund (202) 692-8160 to have it included in the list.

There is no set schedule for implementation of new features. They will be taken care of when time permits.

1. What happened to the read boundary conditions without override?
ANS: Good question. I forgot.

REFERENCES.

1. Fuller, A. L., Bjorklund, F. R., Ship hull form generation using interactive graphics, Naval Ship Engineering Center, NAVSEC 6114B2, Washington, D.C. 20362.

2. Fuller, A. L., Billingsley, D. W., Aughey, M. A., Computer aided ship hull definition at the Naval Ship Engineering Center, September 1978, Proceeding of the SCHAD'77 , computer aided hull surface definition symposium, the Society of Naval Architects and Marine Engineers, One World Trade Center, New York, N.Y.

USERS EXPERIENCE WITH THE HULDEF PROGRAM

Kenneth W. Pleasant.
Newport News Shipbuilding and Dry Dock Company
Newport News, Virginia

Mr. Pleasant is Mold Loft Supervisor, responsible for training, development and use of Newport News computer aided lofting systems. Mr. Pleasant has been with the Newport News Mold Loft for 15 years. He has been a supervisor for the past 6 years, specializing in the implementation and development of AUTOKON and other computer aided systems.

I. OVERVIEW OF THE HULDEF PROJECT

HULDEF is a computer aided program for defining a ship's surface. In addition HULDEF generates ship's lines and offsets and provides the ability to store frames in a database with the use of AUTOKON's TRABO module. HULDEF has modules or job options that allow the application of most manual fairing techniques.

I-1 GENERAL INFORMATION

The purpose for undertaking the project was to determine if HULDEF is a better and/or more efficient means of obtaining faired lines than the current computer aided methods used at Newport News Shipbuilding. To determine this, several vessels of various types were used, varying from small hard chined boats to large merchant ships with and without a-bulbous bow.

The scope of the project included the following items:

- Convert the HULDEF program to make it compatible with our computer system.
- Familiarize Mold Loft personnel with the capabilities and use of the program.
- Select and attempt the fairing of several types of vessels using HULDEF.
- Store the faired lines in a database using AUTOKON'S TRABO .
- Run other AUTOKON modules such as LANSKI, SHELL, AND TEMPLATE against the stored faired lines.
- Determine if HULDEF is a better and/or more efficient means of obtaining faired lines than the current computer aided methods used at Newport News Shipbuilding.

- Make any suggestions as to possible program enhancements and identify any program bugs.
- Report on the HULDEF project.
- Host a workshop in the use of HULDEF for all REAPS shipyards.

Our evaluation in no way covers all environments or aspects of the program. We merely tried to simulate production in our Loft, since this is where all final fairings are done as opposed to a design environment. The methods used in no way suggest the only or most appropriate for the vessels used in the examples. The methods were selected after examining the HULDEF User's Manual and meeting with M.E. Aughey (Naval Ship Engineering Center) and J.R. Vander Schaaf (IITRI) to resolve problems discovered during the course of the project and to discuss fairing techniques related to HULDEF .

I-2 PROJECT DEVELOPMENTS

Upon receipt of the HULDEF program by Newport News Shipbuilding, our computer support department began making modifications to make it compatible with our computer system. The modifications are listed in the Appendix.

After a period of familiarization of the program by the participants several vessels were selected and subsequent fairings were attempted. The fairing exercises continued until bugs and deficiencies discovered proved detrimental to successful completion of the project.

The bugs discovered were as follows:

- Inaccurate plot output
- Inability of DIF12 module to.plot output correctly on the C.R.T.
- Inability to load half stations to a database using TRABO

The deficiencies discovered were as follows:

- Incorrect and unclear program documentation
- Extraneous pen moves before plotting
- Inability of DIF12 module-to give differences at data input points
- The limiting of the user to only ten (10) 206 cards used to slice frames

As stated earlier, Newport News participants met with M.E. Aughey and J.R. Vander Schaaf as a result of the program bugs and deficiencies discovered. Each bug and deficiency was addressed individually and acceptable solutions were identified. The bugs related to plotting were said to be an internal conversion problem. Mr. Aughey assured us that this problem would definitely be looked into along with the other bugs.

The project was suspended for several months at Newport News Shipbuilding until the fixes were made. As a result of the problems found with the program a new version with additional features and capabilities was sent to Newport News Shipbuildirlg for testing.

Further testing resumed .and at the conclusion of the project only two problems were outstanding. The WIND option does not work properly and the program does not generate stations correctly in way of both the bulb and stem in the example of the ship with the bulbous bow. The examples in the Appendix show the graphic results of the testing during the course of the project.

After conferring with Mr. Vander Schaaf concerning the aforementioned problems we concluded that the WIND option works properly in accordance with the way the HULDEF program is written. It was also found out-that the program does generate stations correctly in way of both the bulb and stem if the centerline profile is defined in a specific manner not detailed in the current documentation.

I-3 NEWPORT NEWS CONCLUSIONS

It was decided by the participants that HULDEF is a better and more efficient means of obtaining faired lines than the current computer aided methods used at Newport News Shipbuilding for some of the following reasons:

- The program is a surface definition rather than fairing program allowing the use of most manual fairing techniques.
- The program's use of the parametric spline (a mathematical model of the draftmants spline) for curve fitting ensures that input data points do not move as they do in other computer aided fairing programs.
- There are several auxiliary modules that allow the application of most manual fairing techniques.
- A number of views may be requested and plotted at four place decimal accuracy.
- The program has the ability to calculate preliminary hydrostatic values of the hull form at the specified waterline at any point during the fairing.

Newport News Shipbuilding participants are basically pleased with the features, capabilities and most of all, the ease of use o-f HULDEF; consequently, this program will be used in future fairings.

II-1 NEWPORT NEWS SHIPBUILDING PARTICIPANTS

1.	R.C. Moore	N.C. Coordinator and Project Leader
2.	J.D. Snyder, III	Computer System Support
3.	K.W. Rayhorn	N.C. Programmer and Hull Definition User
4.	P.A. Fitzhorn	Mold Loftsman and Hull Definition User
5.	G.M. Branch	N.C. Programmer and Hull Definition User

APPENDIX

FAIRING EXAMPLE 1 (FORWARD BODY OF A TANKER WITH BULBOUS BOW)

An attempt was made to fair the forward end of a tanker with a bulbous bow. This type vessel was decided upon to determine how HULDEF would handle the bulb and adjacent regions. Also, the bulbous bow has been known to be a problem area in fairing ships; so this was thought to be an excellent test example. The attempted fairing was with the bulb attached.

The ship chosen was a Liquid Natural Gas Carrier with principal particulars as being:

Length	OA	- 948.5′
Length	BP	- 906.0′
Beam	MLD	- 135.0′
Draft		- 36.0′

In defining the vessel, the centerline profile, flat-of-side, flat-of-bottom, 95 ft. waterline and station 7 were defined as control lines. An offset line was generated using the OFFSET module at .01' away from the flat-of-side and flat-of-bottom to ensure a smooth transition into these flat regions. See figure II-1. At this point the stations were input as display lines as shown in figure II-2. Next, the centerline profile, stations, flat-of-side and station 7 were intersected at desired heights using the INTLP module. The intersections were used to create waterlines and a preliminary body plot. See figure 11-3. The waterlines were then intersected with diagonals in the stem region again with the INTLP module. Diagonals were selected′ in way of the bulb and their intersections with the stations were used to create the bulb diagonals as shown in figure 11-4 along with corresponding body plot. The time involved in achieving this body plot was approximately 80 hours.

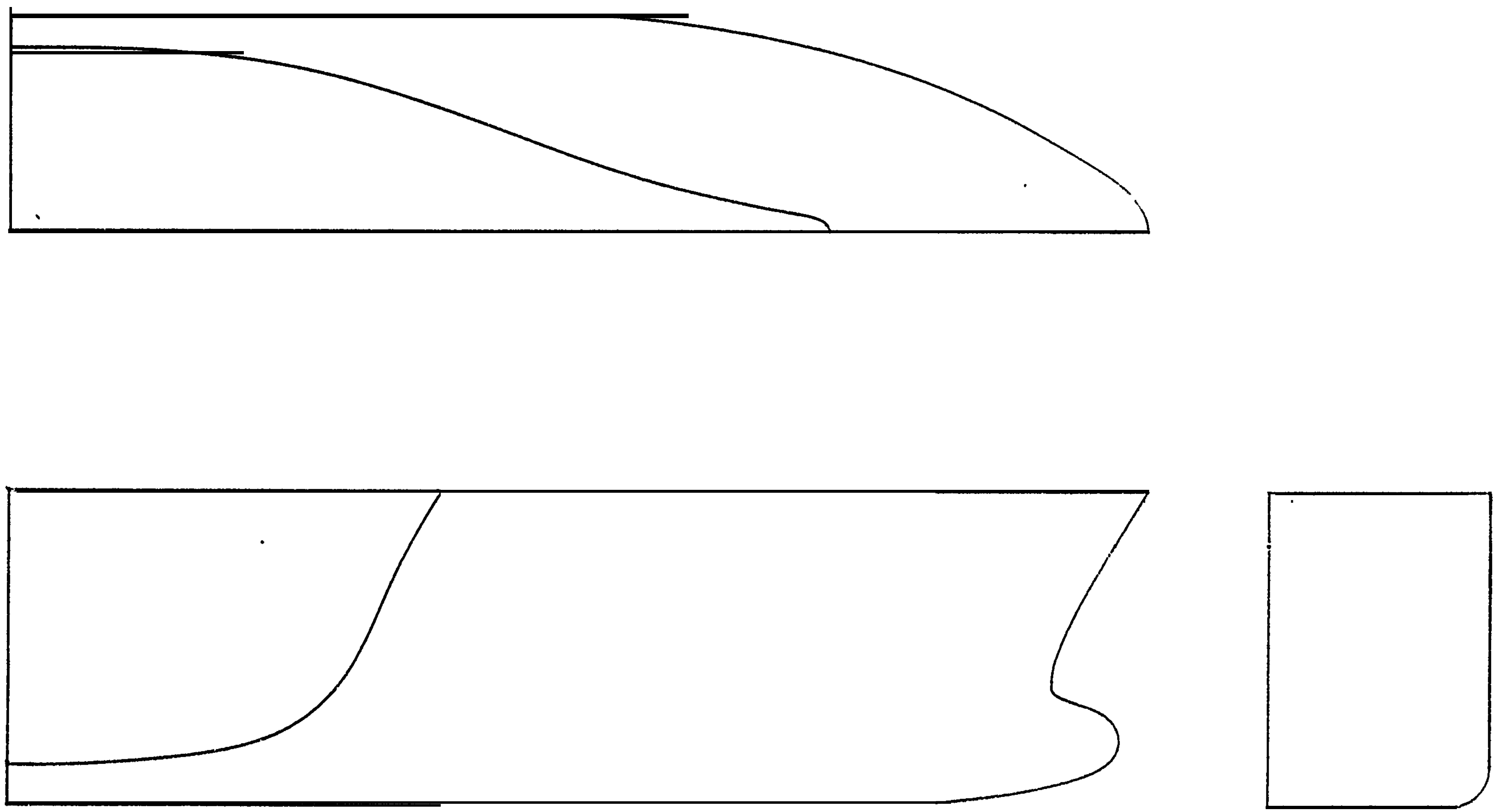


Figure I Conventional views Control lines

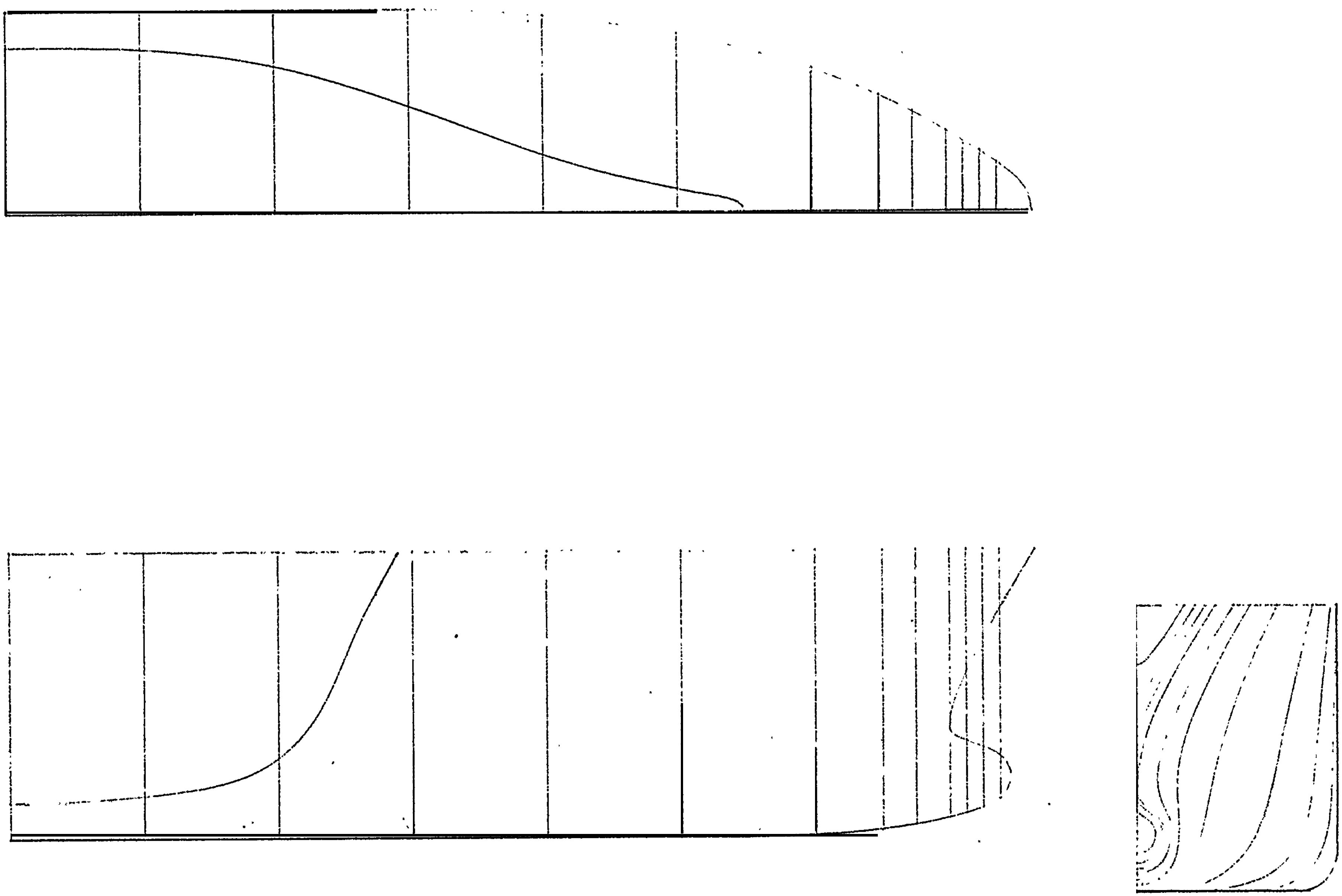


Figure II-2 Conventional three views of Control lines and Stations

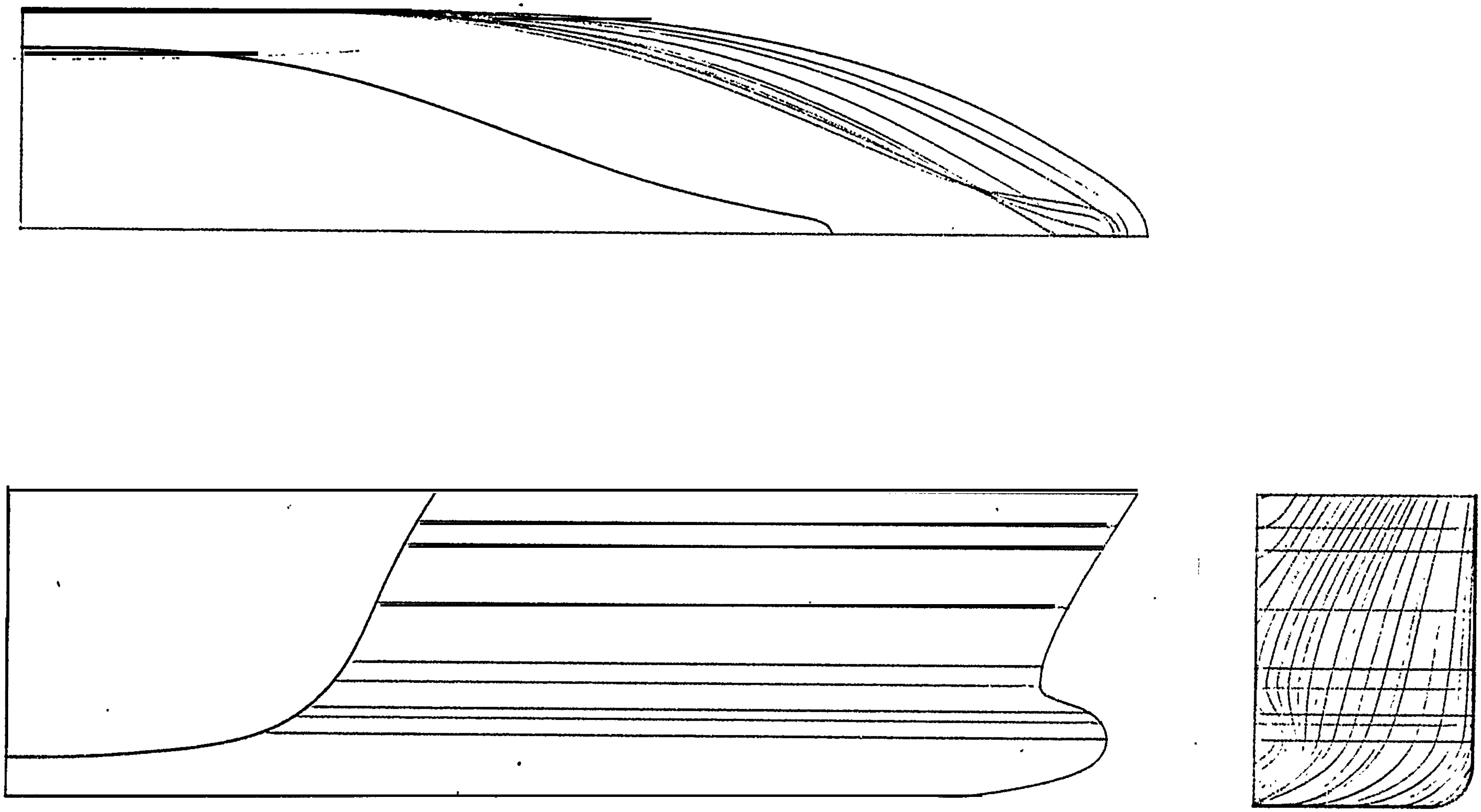


Figure II-3 Elevation and plan views of reference lines and corresponding body plot

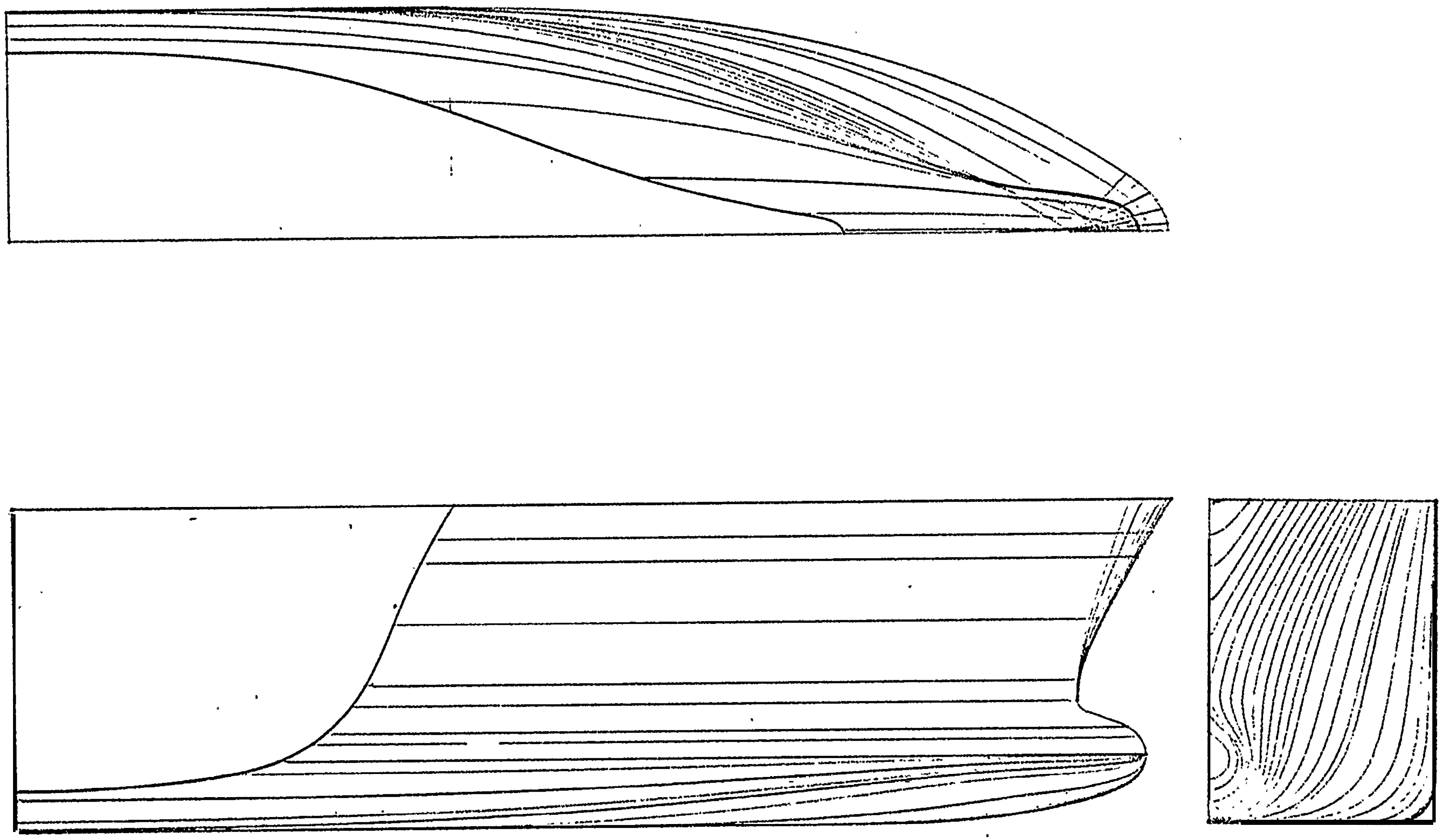


Figure I-4 Elevation and plan views of final reference lines
and corresponding body plot

FAIRING EXAMPLE 2 (FORWARD SECTION OF AN OCEAN' LINER)

A. The Ship used for this example is the T.S.S. Carnivale, an ocean liner of principal dimensions:

Length OA -	635'
Length BP -	616'
Beam MLD -	85'
Draft	28.9'
Deadrise	6" in 42.5' Half Breadth
Bilge Radius	11.25'

The example, although used to test the program, was in this shipyard for overhaul and repair of some damaged framing and shell plating. Consequently, only the forward half (containing the damaged area) was defined. Figure 11-5 is the completed traditional three view lines drawing of the example.

B. This example is similar to the Series 60 Merchant Type hull fully developed in the HULDEF documentation. The user attempted to utilize the documentation to reproduce those results for this example. Two other methods of definition not outlined in the documentation were also attempted as additional tests for the program.

C. First, a data file was created using the station ordinates, flat-of-side data, flat-of-bottom data, deck and centerline profile from the design offsets. Figure II-6 is the graphic output of that file. Approximately 40 hours were used to create the file.

D. The first method used to develop the hull. surface, as explained in the HULDEF documentation, took the longest time of the three methods used. It required approximately 100 hours to 'complete this file.

1. First," fractional girths were generated from the stations, along with the beginning and ending tangents at each station input point.

2. Diagonals were then. generated, starting at the intersection of the stera and deck, and running through the intersection of the girths and a convenient station. The beginning and end tangents at each station were also found.

3. The girths and diagonals were joined at their intersections along with the proper beginning and end tangents to maintain continuity.

4. This information was used to create a new data file.

Comments

The length of time required to complete the first method of hull definition was needed due to the need to determine two different families of lines, (i.e. girths, diagonals), then find the required tangents, delete any portion of the lines extending past the intersection and piece the information together to form the file. Several areas, notably at the stem, are void of any control and would still. need additional definition.

E. The second method used was to entirely eliminate the diagonals; defining the ship with fractional girths only. This was made possible by editing the original HULDEF data file containing the stations. A "dummy" station was created at the intersection of the stem and the deck (straight line from stem to baseline),- and extensions of the next two stations from the centerline, to the baseline, figure II-7, This continuity of stations from the deck edge to the baseline created a family of girths able to define the surface by themselves. The approximate time required to complete this file *was* 60 hours.

1. Fractional girths were generated from the altered. HULDEF, data file as in paragraph D-1 above.

2. The intersection of each girth with the centerline at the bow was generated and inserted in the new data file. All girth data forward of the centerline was then deleted.

Comments

Using girths alone saved a large amount of time over the' previous method. It also provided better definition of the area near the forefoot and at the stem, as the girths end on the stem and not at the intersection of the stem and deck.

F. The last method attempted utilized waterlines as the family of lines for surface definition. This was done as a test to determine if waterlines could adequately define the hull surface in a shorter time period than the other methods. As the total hull surface of the example could be defined by a family of waterlines,"hull continuity could still be maintained. The results showed that in a significantly shorter time, the example could be adequately defined by waterlines. However, the hull of the example is quite different from most ships faired at larger shipyards. Bulbous bows, no deadrise, knuckles, etc. would render definition with waterlines virtually useless. It is included here only to show that the HULDEF user has a number of techniques available which, when used alone or in combination with other methods, should optimize the definition of a hull form. The approximate time required to complete the file was 30 hours, which represents a large savings. of time over the other two methods.

1. A HULDEF auxiliary module, INTLP, which intersects lines and plans was used to determine the intersection of the waterline planes with the stations in the original HULDEF data file. One

further advantage of the INTLP module is the ability to locate the intersections of the centerline with the waterline planes at the same time.

Therefore, at the bow of the ship, no extraneous data was generated which had to be deleted at a later time, as in the other methods.

2. When the waterline information.was used to create a new HULDEF data file, Figure 11-9. resulted.

Comments

One interesting sideline occurred with an input station which was known to be producing inflections in the waterlines. After that station was deleted and new waterline intersections found and plotted, they came out smooth through that region, producing a fair station.

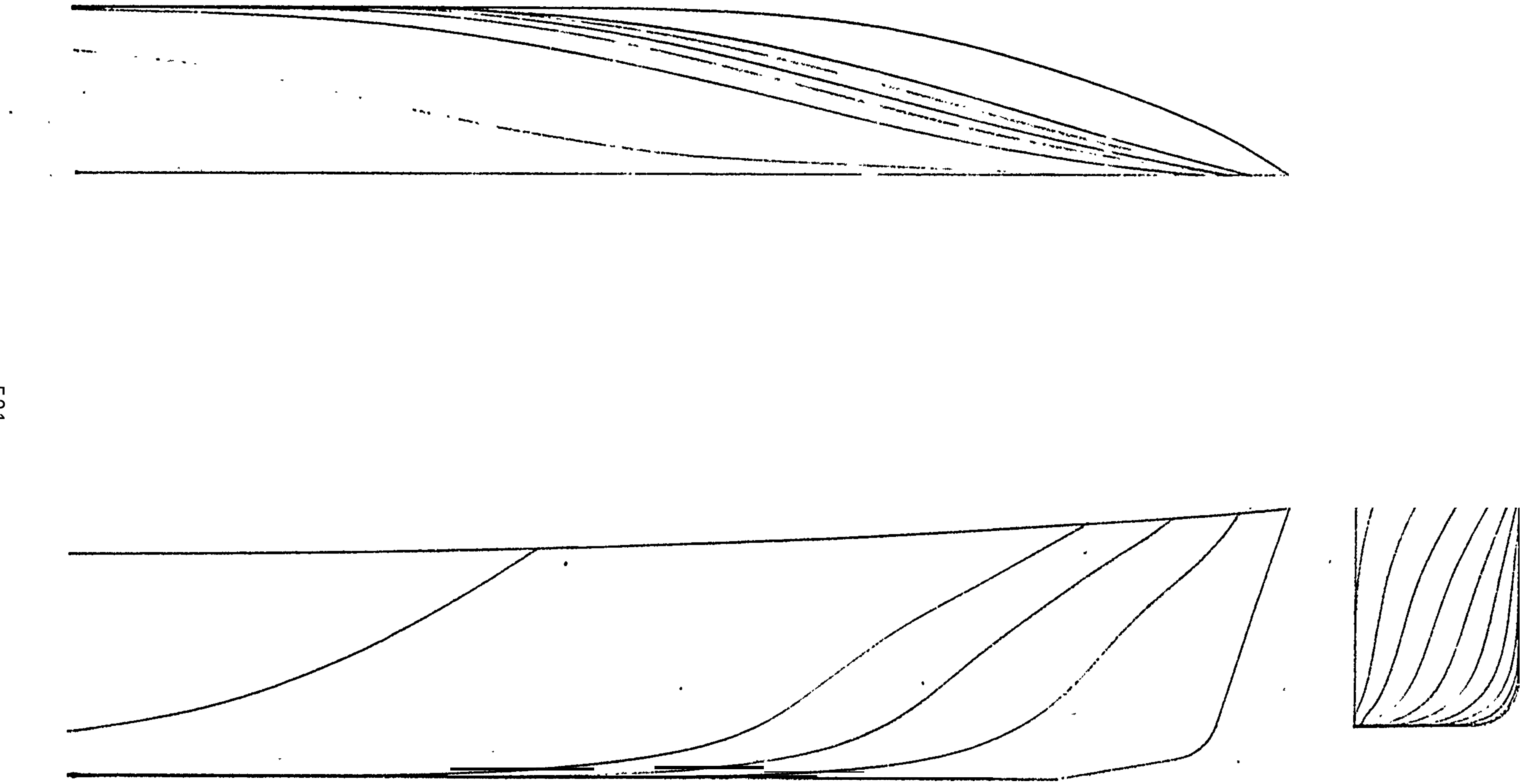


Figure II-5 Traditional three views of Buttocks, Waterlines, and Stations

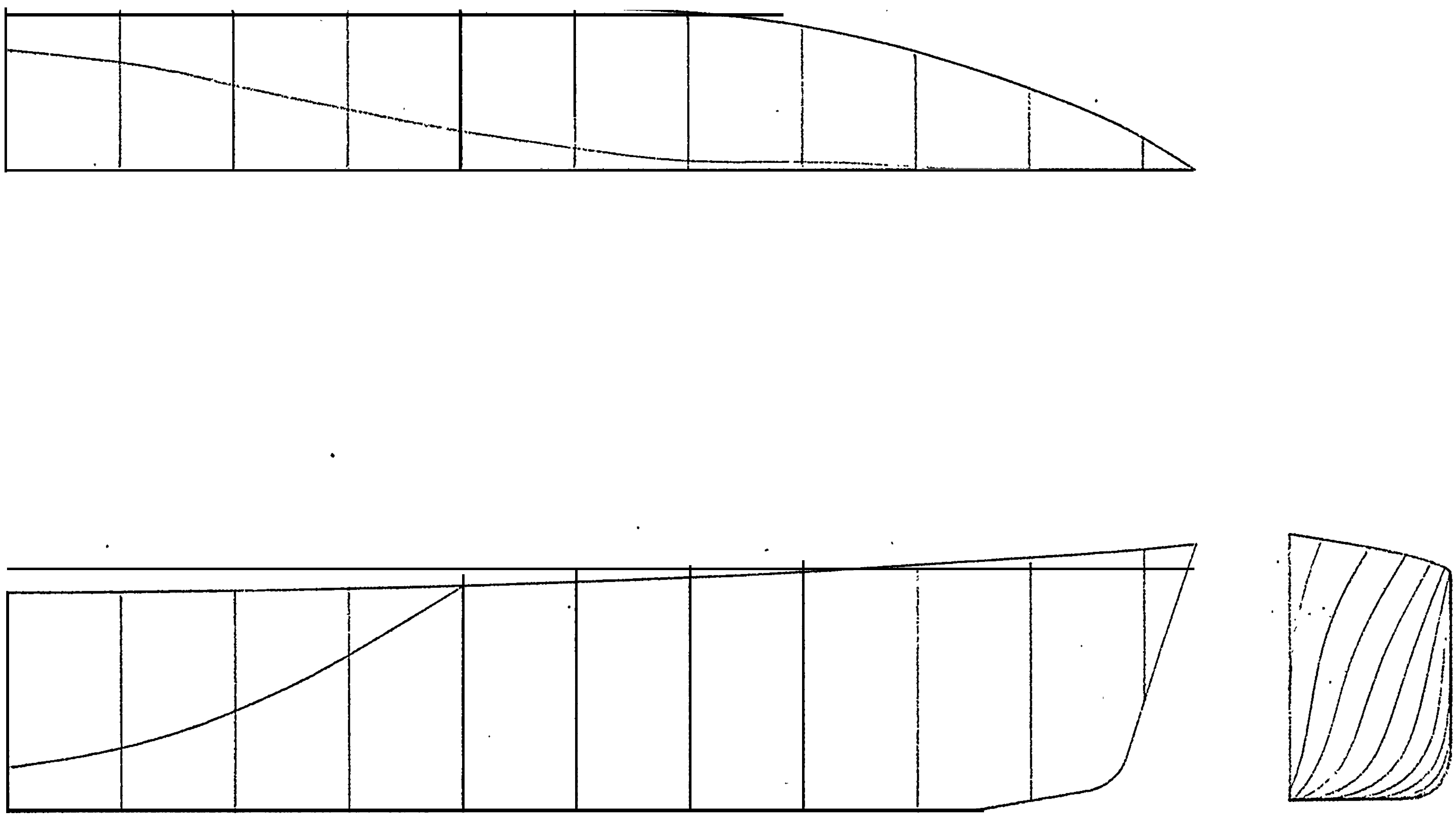


Figure II-6 Conventional three views of Control lines and Stations

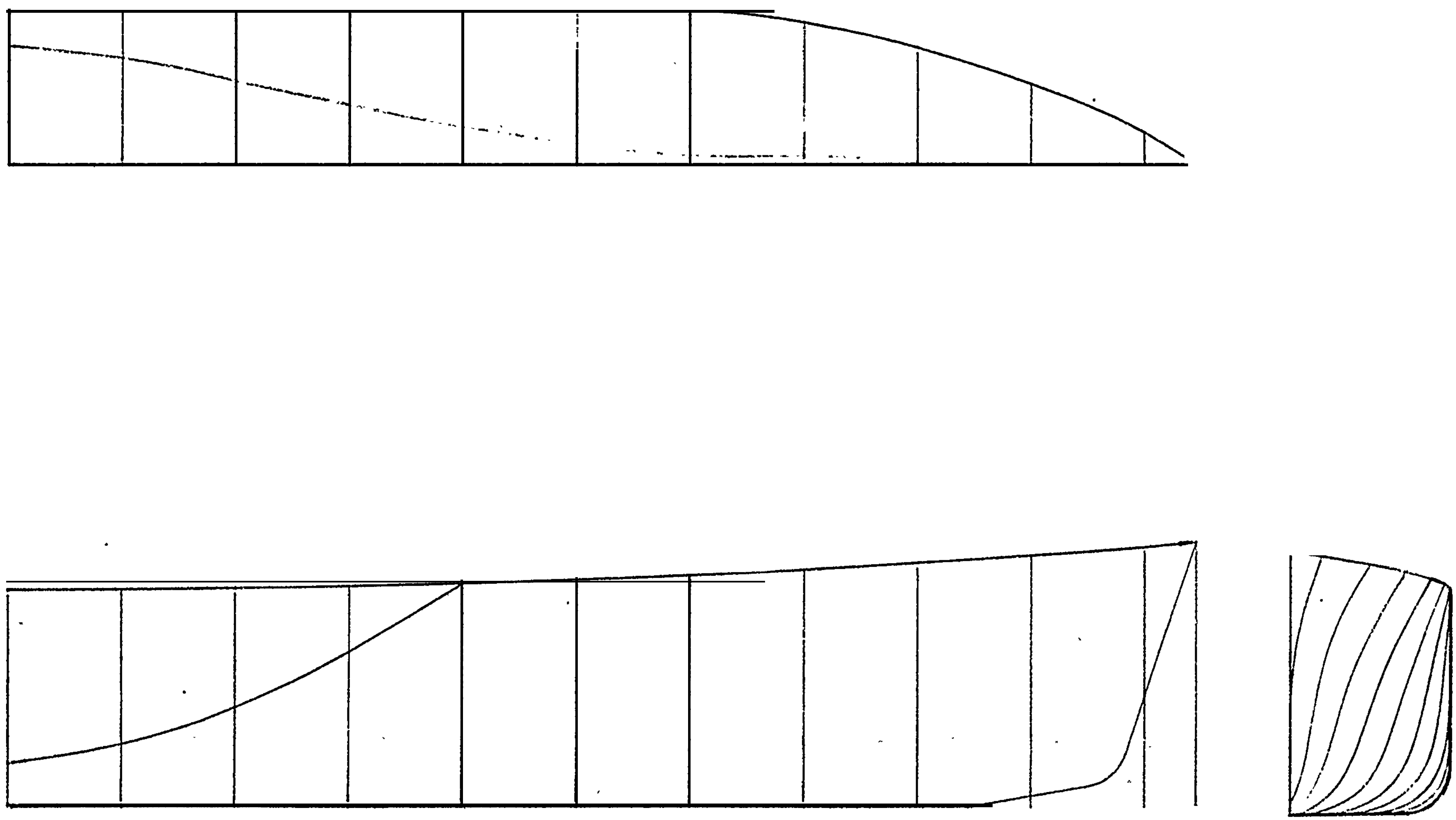


Figure [illegible] e views of Control lines and extended forward Stations

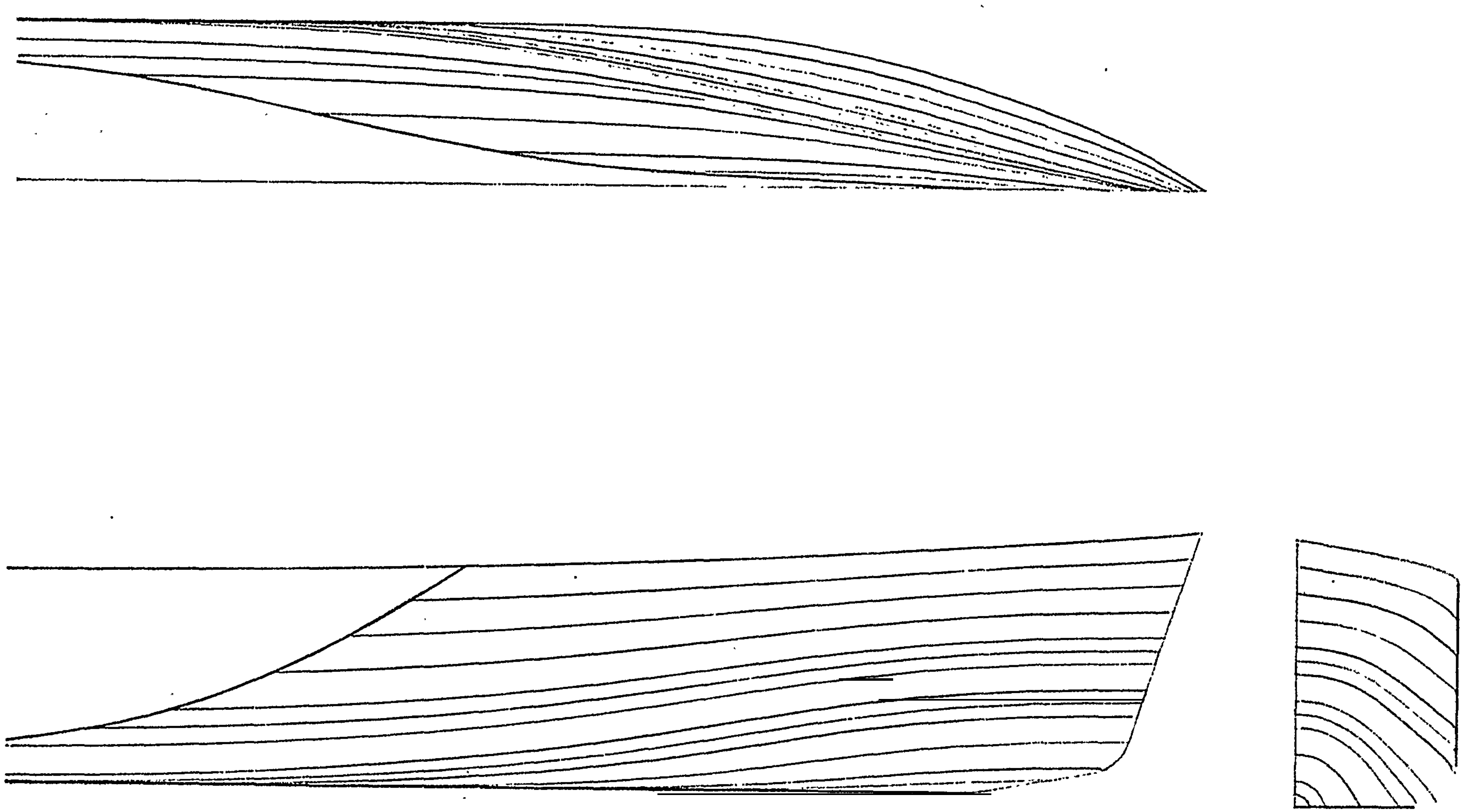


Figure II-8 Three views of Control lines and Iso-girth lines

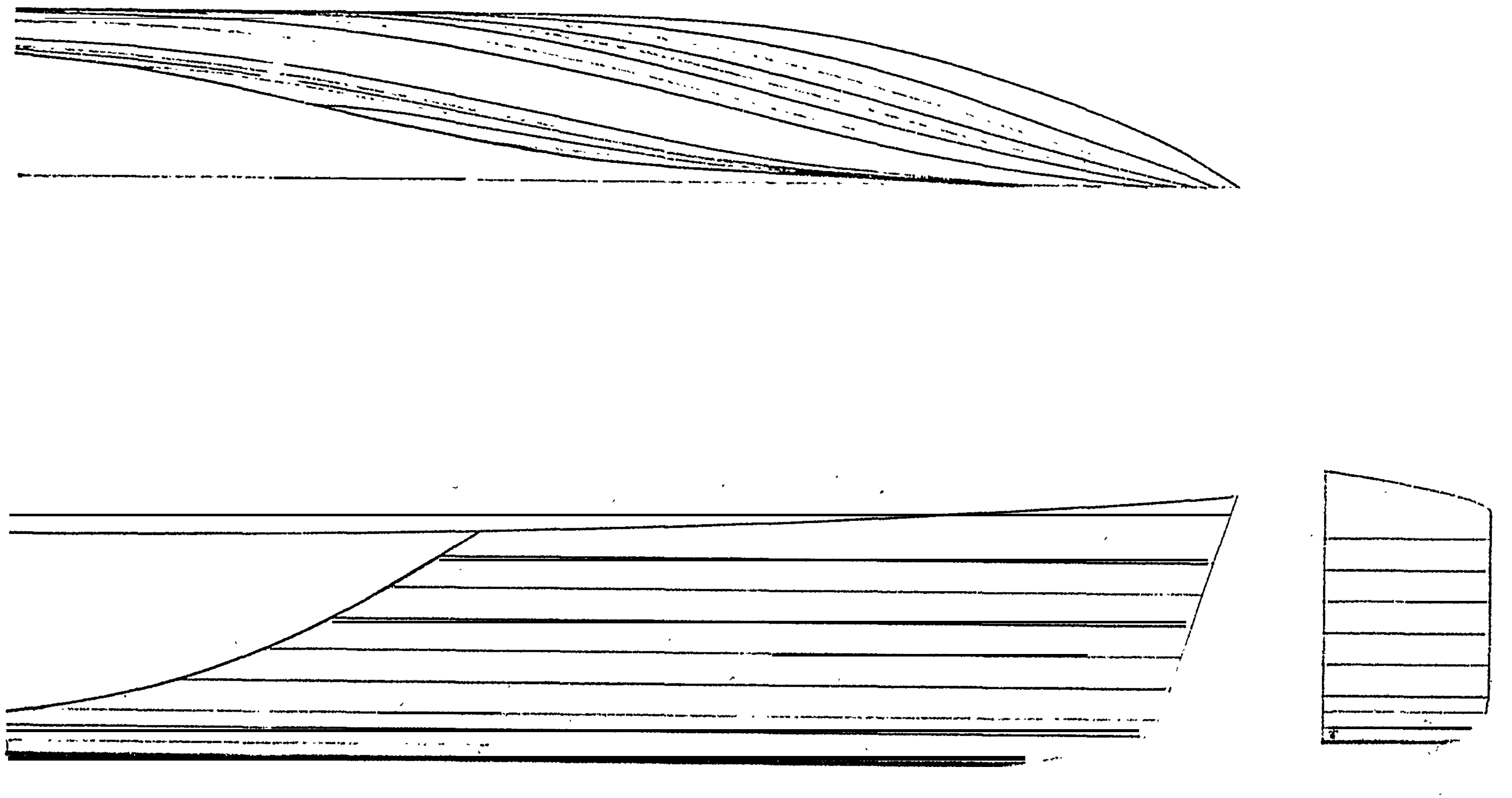


Figure II-9 Three views of Control lines and Water lines

FAIRING EXAMPLE 3, (A HARD CHINED, BOAT)

The definition of a small boat (36 feet overall) was done using hand written offsets as original data. There was no flat-of-side or flat-of-bottom on the vessel and was originally intended to have, 'distinct chines.

The initial attempt was made using as little data as possible, namely the deck line, sheer line, centerline, and a tangency line (inboard of which the stations were straight) as the only data. This resulted in Figure II-10 and proved to have too little control. After using the DIF12 module to determine minor adjustments needed, and adding the five foot design waterline, Figure II-11 resulted.

After changing a few more data points, these five lines met the users criteria of fair, so the FRACG module was used to get several additional data points for station definition. Figure II-12 was the result of using girths of 5, 10, 25, 40, 50, 60, 75, and 90 percent.

The output from FRACG was then used with the INTLP module to get station intersections at these girths. Selected points were then combined with the original five lines to get a "fair" ship. The resulting plots looked similar to Figure 11-11. The PRBO option was used and the printed book of offsets were compared to the hand written offsets. The comparison was favorable for test purposes (less than 1/8" difference in all cases) and ready to transfer to test database.

At this point it was decided to add a skeg to the ship. To do so, several more control lines were needed to get into the skeg and down to the baseline.

The EFIL option was now used (along with REVR to reverse the coordinate system to the AP) to set up a file to be transferred by the Autokon Program TRABO. Since HULDEF automatically numbers transverse sections from 101 on, and TRABO interprets these numbers as 1.01, 1.02, l.03--- etc., several runs were needed due to users errors to get the desired frame numbers (O, .5, 1, 1.5, 2, --- etc.) stored in the database.

The transferred contour matrices were listed and appeared to be in the proper format for other Autokon modules, so the LANSKI Program was used to define several longitudinal curves. The ship was treated as a whole, as well as a forward section and an aft section. All the plots and printouts generated by LANSKI compared favorably with the original offsets and the HULDEF plots.

A total of 120-160 manhours was used to do this portion of testing of the HULDEF Program.

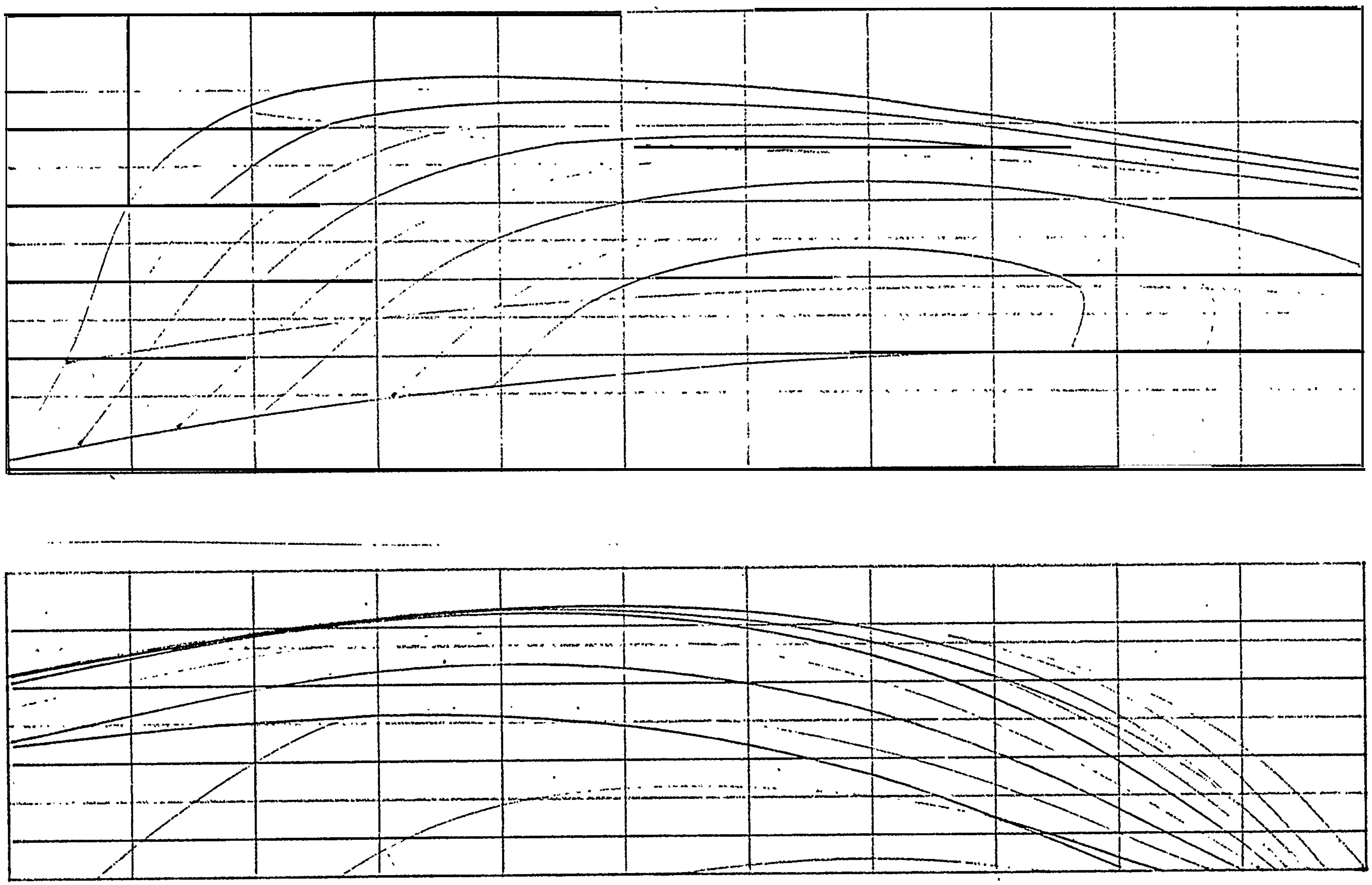


Figure II-10 Traditional three views of Buttocks, Waterlines, and Stations

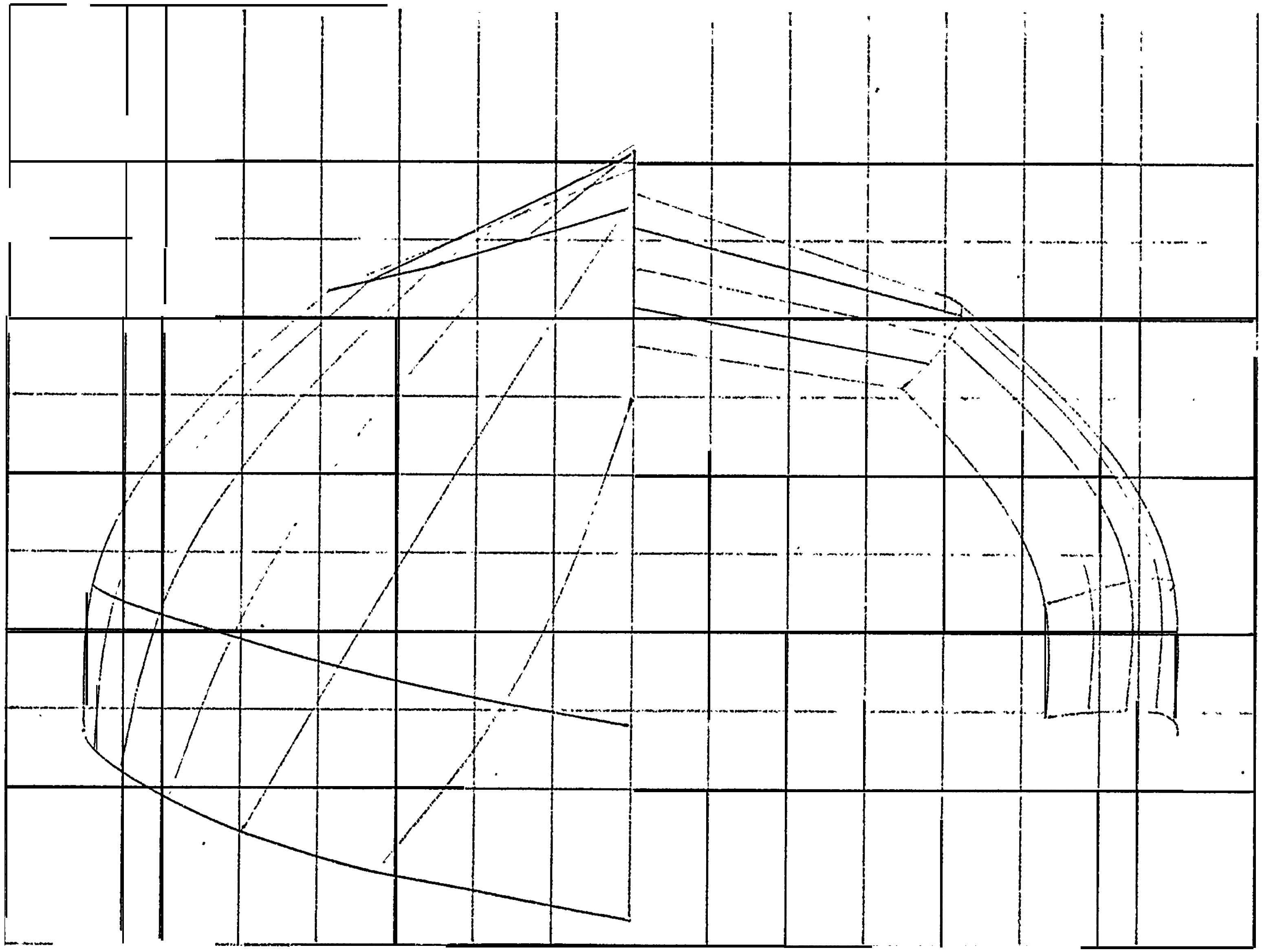


Figure II-10 (concluded)

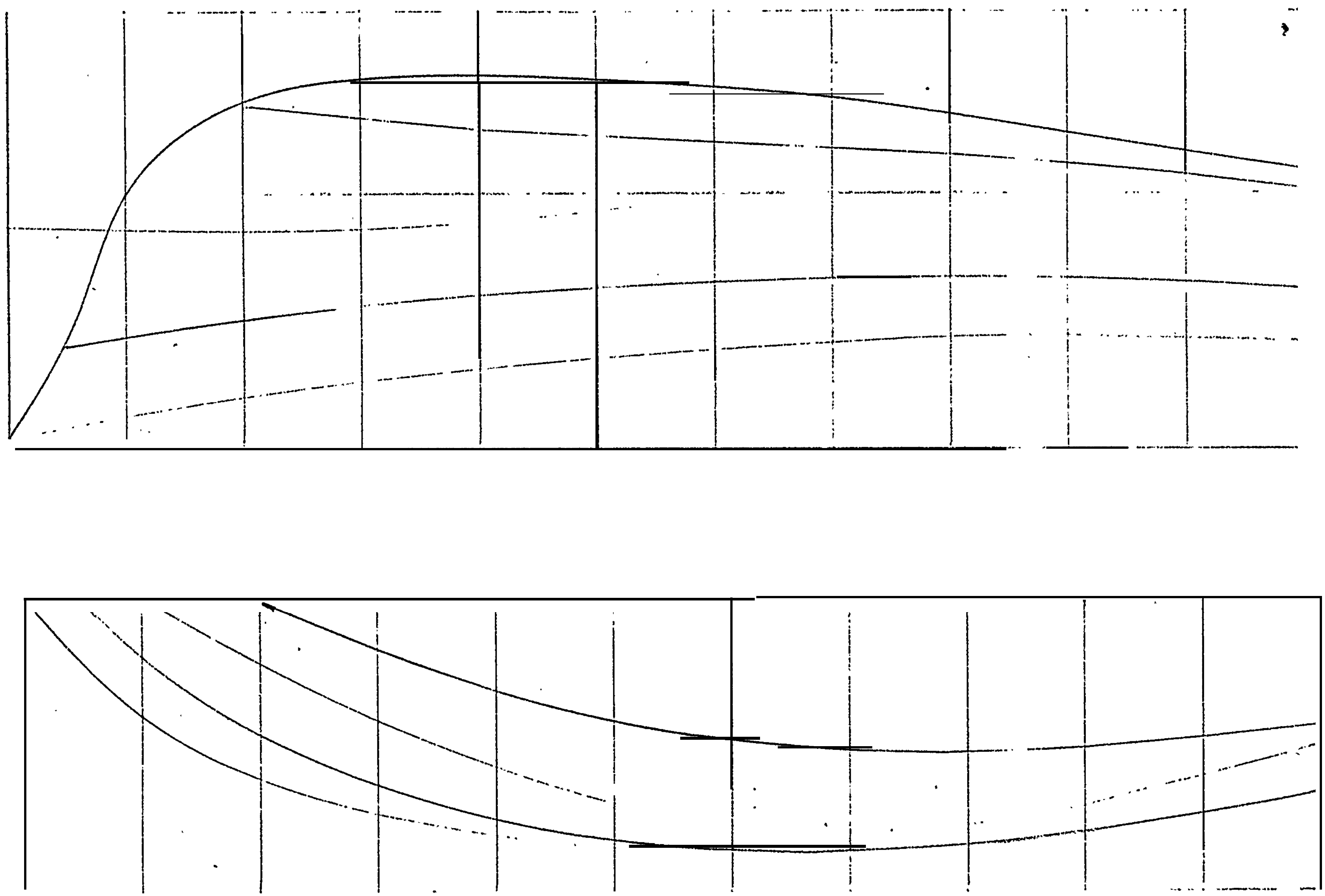


Figure II-11 Conventional three views of Stations and Reference lines

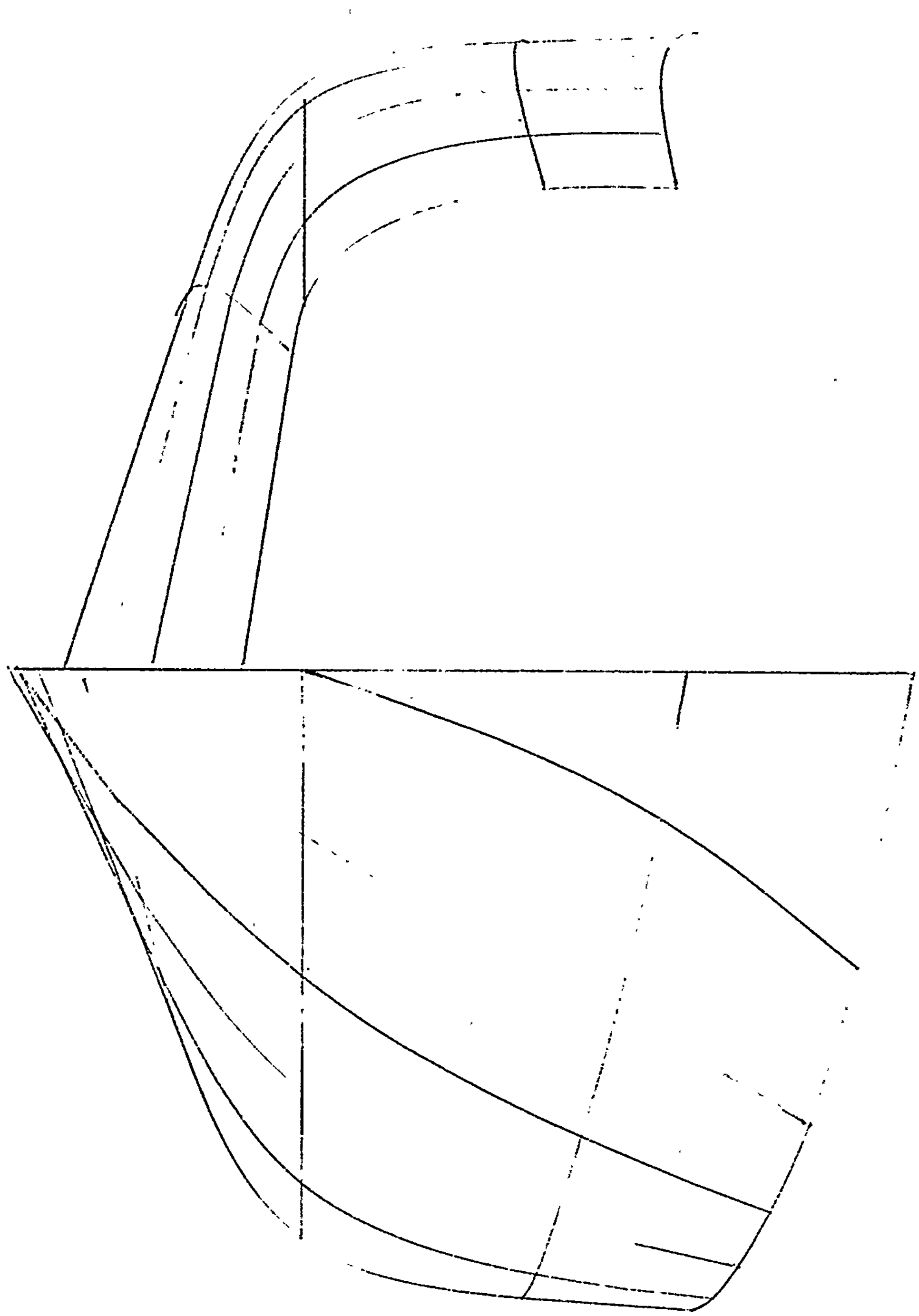


Figure II-11 (concluded)

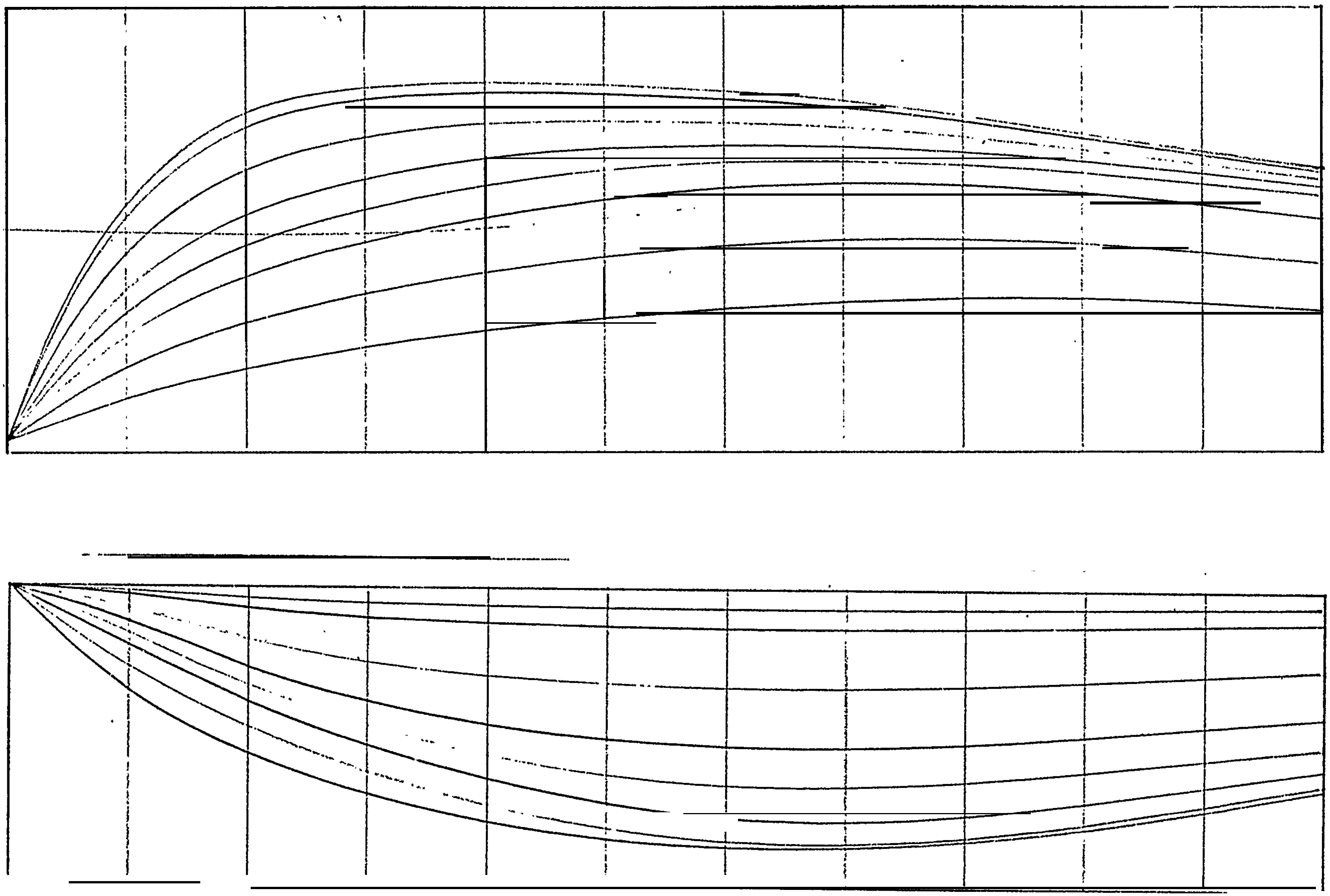


Figure II-12 Conventional three views of Stations and Iso-girth lines

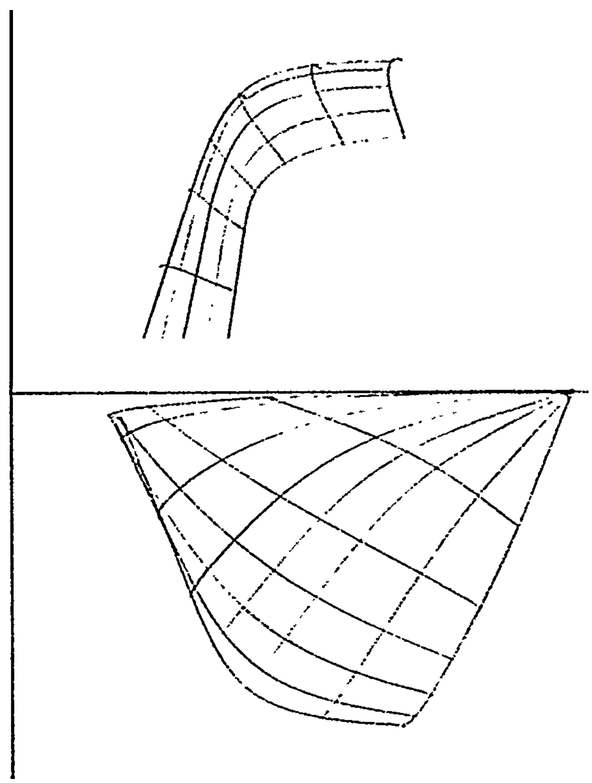


Figure 11-12 (concluded)

APPENDIX A

REAPS TECHNICAL SYMPOSIUM AGENDA

TUESDAY, JUNE 27

8:00 -5:00 REGISTRATION **LOWER LOBBY**

9:00 GENERAL SESSION **MAYAN BALLROOM**

WELCOME
hf. Pitkin, Maritime Administration, U.S. Department of Commerce

A PROGRESS REPORT ON THE REAPS **PROGRAM**
D.J. Martin, IIT Research Institute

PRESCRIPTION A NATIONAL EFFORT FOR IMPROVED PRODUCTIVITY IN SHIPBUILDING
J. Hallett, National Center for Productivity and Quality of Working Life

10:00 INFORMAL DISCUSSION PERIOD

10:30 GENERAL SESSION **MAYAN BALLROOM**

SAVING PRODUCTION MANHOURS THROUGH IMPROVED DESIGN OFFICE PROCEDURES
T.P. Gallagher. Naval Ship Engineering Center

AN APPROACH FOR USE OF INTERACTIVE GRAPHICS IN PART DEFINITION AND NESTING
A.F. Kaun, Newport News Shipbuilding & Dry Dock Co.

COMPUTERS IN SHIP DESIGN AND PRODUCTION: NECESSARY STEPS TO THE PAYOFF
B.M. Thomson, Naval Ship Research and Development Center

12:00 LUNCH

1:30 PARALLEL SESSIONS

SESSION 1 **MAYAN BALLROOM**

MAPS-GP (**GRAPHIC PIPING): PRESENT AND FUTURE CAPABILITY**
T. Hirano and K. Kobayashi Mitsui Engineering and Shipbuilding Co., Ltd.

PRODUCTION USE OF THE RAPID **SYSTEM FOR PIPING DESIGN**
P.W. Rourke, Newport News Shipbuilding & Dry Dock Co.

SE5SION 2 **SALONS I, II AND III**

NEW SRS N/C SOFTWARE SYSTEMS DEVELOPMENTS
P. Sorensen, Shipping Research Services, A/S

THE DETAIL ENGINEERING MODULE (DEMO) AND OTHER SPADES DEVELOPMENTS
A. Schulze, Cali & Associates, Inc.

2:45 INFORMAL DISCUSSION PERIOD

3:15 PARALLEL SESSIONS

SESSION 1 **MAYAN BALLROOM**

COMPUTER-AIDED DESIGN SYSTEMS APPLIED TO SHIP PIPING DESIGN
A.G. Reinhold, Computervision Corp.

THE AUTOFIT **PIPING DESIGN SUBSYSTEM IN USE**
P. Sorensen. Shipping Research Services A/S

THE HITACHI HICAS **SYSTEM**
M. Ueda and Y. Yamamoto, Hitachi Shipbuilding & Engineering Company

SESSION 2 **SALONS I, II AND III**

COMPUTER-AIDED COST ESTIMATING
G. uberti~ National Steel & Shipbuilding Co.

THE SPADES SHIP PRODUCTION AND CONTROL (SPAC) MODULE
F. Cali, Cali & Associates, Inc.

IMPROVED SHIPYARD CONTROL WITH TOMAS **(TOTAL MANAGEMENT SYSTEM)**
A. Manchinu. Shipping Research Services, Inc.

5:15 -6:30 RECEPTION **THE GALLERY**
Sponsored by
IIT Research Institute

WEDNESDAY, JUNE 28

8:00 -3:30 REGISTRATION **LOWER LOBBY**

9:00 PARALLEL SESSIONS

WEDNESDAY, JUNE 28 (CONTD)

SESSION 1 **MAYAN BALLROOM**

USER'S GUIDE TO INTERACTIVE LINES GENERATION WITH A STORAGE TUBE
A.L. Fuller and F.R. Bjorklund, Naval Ship Engineering Center

USER EXPERIENCE WITH THE HULDEF PROGRAM
K.W. Pleasant, Newport News Shipbuilding & Dry Dock CO.

SESSION 2 **SALONS L II AND III**

NEW DEVELOPMENTS IN CNC AND DNC CONTROLLER EQUIPMENT FOR THE SHIPBUILDING INDUSTRY
T. Bue, Kongsberg Systems, Inc.

DNC/CNC PLATE CUTTING AT BATH IRON WORKS
R.M. Morgan, Linde Welding Products and G.H. Peck. Bath Iron Works

10:15 INFORMAL DISCUSSION PERIOD

10:45 PARALLEL SESSIONS

SESSION 1 **MAYAN BALLROOM**

A USER'S VIEW OF THE SPADES HULLOAD PROGRAM FOR SPECIFYING SHIP STRUCTURE
E.E. Mayer, Livingston Shipbuilding

PRACTICAL APPLICATIONS OF AN INTEGRATED DATABASE FOR COMPUTERIZED GRAPHICS IN DESIGN AND PRODUCTION
B. Enoch, United Computing Corp.

SESSION 2 **SALONS I, II AND III**

STEEL HANDLING AT NASSCO
C.W. Jensen and L.E. Hoffman, National Steel and Shipbuilding Co.

COLD TWIST FORMING OF LARGE FRAME MEMBERS
S. Rajagopal, IIT Research Institute

12:00 LUNCH

1.30 PARALLEL SESSIONS

SESSION 1 **MAYAN BALLROOM**

IMPROVING LABOR PRODUCTIVITY IN SMALL SHIPYARDS WITH COMPUTER-ASSISTED STRUCTURAL DETAILING
M.R. Ward, RTL, Inc.

AUTOKON ON **A MINICOMPUTER**
D.K. Medler and J. Harper, Designers and Planners, Inc.

SESSION 2 **SALONS I, II AND III**

A PORTABLE WELDING ROBOT FOR THE SHIPYARD
T.H. Lindbom, Unimation, Inc.

THE APPLICATION OF NASA\AEROSPACE WELDING TECHNOLOGY TO THE SHIPBUILDING INDUSTRY
E.R. Bangs, IIT Research Institute

2:45 INFORMAL DISCUSSION PERIOD

3:15 GENERAL SESSION **MAYAN BALLROOM**

INCREASING SHIPBUILDING PRODUCTIVITY THROUGH USE OF STANDARDS
J. Mason, Bath Iron Works

IMPROVEMENT OF MATERIAL UTILIZATION AND PRODUCIBILITY THROUGH STANDARD-IZATION
R. Kucharski and R. Butera General Dynamics Corp., Quincy Shipbuilding Div.

HIGHLIGHTS OF THE 1978 KONGSBERG SHIPBUILDING SYMPOSIUM
R. Doombos, Shipping Research Services, A/S

5:15-6:30 RECEPTION **THE GALLERY**
Sponsored by
KONGSBERG Systems, Inc.

THURSDAY, JUNE 29

8:00-12:00 **ST. LOUIS SHIPBUILDING TOUR**

IITRI

APPENDIX B

REAPS TECHNICAL SYMPOSIUM ATTENDANCE LIST

REAPS TECHNICAL SYMPOSIUM

Bel Air Hilton
St. Louis, Missouri

June 27-28, 1978

A&P APPLEDORE LTD.
Northumbrian Way
Illingworth, Newcastle-Upon-Tyne
England

A. W. Allan
Senior Consultant

S. Forbes
Senior Consultant

AVONDALE SHIPYARDS, INC.
P.O. Box 50280
New Orleans, Louisiana 70150

Vincent Nuzzo
Assistant Supervisor

BATH IRON WORKS CORP.
700 Washington Street
Bath, Maine 04530

S. C. Endris
N/C Project Manager

John Mason
Product Engineer

J. L. Steiner
Sr. Project Planner-FFG

BETHLEHEM STEEL CORPORATION
Sparrows Point Shipyard
Sparrows Point, Maryland 21219

Robert V. Beck
Superintendent-Plng, Mat. Cntrl & Optical Detail

Bruce G. Bohl
Lead Programmer/Analyst

W. C. Brayton
Asst. to General Manager

John Eckenrode '
Lead Programmer/Analyst

Nicholas V. Haynes
Superintendent-Production Engrg & Incentive

C. ITOH & COMPANY
2-4, Honcho Nihonbashi
Tokyo, Japan

T. Inoue

C.ITOH & COMPANY
280 Park Avenue
New York, New York

Floyd I. Makstein
V.P., Marketing

CALI & ASSOCIATES, INC.
3101 37th St. - Suite 130
Metaire, Louisiana 70001

Filippo Cali
President

Donald P. Ross
V.P. Marketing & N/C Services

Albrecht Schulze
Associate

CAMSCO, INC.
919 Third Ave.-27th Floor
New York, New York 10022

Joseph W. Wade
Manager, Nestamatic System

COLLINGWOOD SHIPYARDS
Collingwood, Ontario
Canada

A. S. Thorns
Systems & Planning Manager

COMPUTEL SYSTEMS
1200St. Laurent Blvd
Ottawa, Ontario, Canada

David R. Perron
Systems Consultant

COMPUTERVISION CORP.
210 Burlington Rd.-Route 62
Beford, Massachusetts 01730

Arnold G. Reinhold
Product Line Manager

CORPORATE-TECH PLANNING, INC.
John Hart Mansion-The Hill
Portsmouth, New Hampshire 03801

James R. McReynolds
Vice President

DAVIE SHIPBUILDING LTD.
P.O. Box 130
Levis, Quebec, Canada

J. P. Boisard
Spec. Proj. Eng.

M. Michaud
Systems Manager

P. W. White
Systems Manager

DESIGNERS & PLANNERS, INC.
P.O. Box 1080
Galveston, Texas 77553

Jack Harper
System Analyst

Dennis K. Medler
Dir. CASD

GENERAL DYNAMICS CORPORATION
Data Systems Services Dept.
7733 Forsyth B1vd.
St. Louis, Missouri 63105

B. J. Breen
Corporate Wide Applications Consultant

R. J. Hollenbach
Appl. Dev.& Plnng Mgr.

GENERAL DYNAMICS CORPORATION
Eastern Data Systems Center
Eastern Point Rd.
Groton, Connecticut 06340

Paul M. Cofoni
Programmer-Analyst

Thomas F. McCarthy
Engineer

David P. Rissanen
Programmer-Analyst

David V. Pearson
Chief Engineer-Drafting & Engr. Services

GENERAL DYNAMICS CORPORATION
Quincy Shipbuilding Div.
Quincy, Massachusetts 02169

Charles E. Bergeron
Loft Foreman

John Brychey
Site Mgr-Data Systems Services

Robert J. Butera
Engineering Specialist

Robert Geary
Director of Engineering

Raymond Kucharski
Computer Applications

Bob Lovett
Sr. Engrg. Asst.

Robert O'Keeffe
Tech. Systems Analyst-Data Systems Services

GENERAL DYNAMICS CORPORATION
Quonset Point Facility
Electric Boat Div.
North Kingstown, Rhode Island 02852

Victor Sibilla
Spvr. Projec. Ind. Engr.

THE GERBER SCIENTIFIC INSTRUMENT COMPANY
83 Gerber Road
South Windsor, Connecticut 06074

C. Peter Van Dine
Senior Applications Specialist

HITACHI ZOSEN
Hitachi Shipbuilding & Engineering Co., Ltd.
Osaka 550, JAPAN

M. Ueda
Chief, Applied Engineering Section

Y. Yamamoto
Info. Systems Dept.

HYDE PRODUCTS, INC.
810 Sharon Dr.
Cleveland, Ohio 44145

T. P. Mackey
Presideht

HYDRONAUTICS, INC.
Ship Engineering Dept.
Pindell School Road
Laurel, Maryland 20810

Stephen H. Klomparens
Naval Architect

IBM
3424 Wilshire Blvd.
Los Angeles, California 90010

J. R. Blackshaw
Consultant

III RESEARCH INSTITUTE
10 West 35th Street
Chicago, Illinois 60616

Edmund R. Bangs
Manager

Margarita Hernandez
REAPS Librarian

Douglas.,J. Martin
REAPS Group Leader

David L. Morrison
Director

George P. Putnam
Manufacturing Advisor

James R. Vander Schaaf
Sr. Naval Architect

John C. Williams
Manufacturing Advisor

Richard B. Wise
Symposium Chairman

JACKSONVILLE SHIPYARDS, INC.
P.O. BOX 2347
Jacksonville, Florida

Chao Lin
Naval Architect

KONGSBERG SYSTEMS, INC.
10 De Angelo Drive
Beford, Massachusetts 01730

William Belanger
Consultant

Reg Diodati
Eastern Division Manager

John Perrin-.
Central Div. Mgr.

LOCKHEED SHIPBUILDING & CONSTRUCTION CO.
2929-16th Ave., S.W.
Seattle, Washington 98134

Tom D. KuhJmeier
Superintendent, Loft/Plate Burning

Elwin Messer
V.P.-Engineering

LIVINGSTON SHIPBUILDING COMPANY
Front & Mill Streets
Orange, Texas 77630

Curtis W. Halliburton
N/C Loft Supt.

Robert G. Gifford
Chief-Hull & Outfitting Sect.

E. Eugene Mayer
Engrg Hull Section Manager

MARINETTE MARINE
Marinette, Wisconsin

Lloyd J. Houle
Piping Engineer

MARITIME ADMINISTRATION
U.S. Dept. of Commerce
Washington, D.C. 20235.

John J. Garvey
Manager; Shipbuilding Research Program

John Hotaling

Joan Forman
Asst. Chief, Engineering Computer Group

Fred Johnson
Chief, Engineering Computer Group

Marvin Pitkin
Asst. Administrator for Commercial
Development

MARYLAND SHIPBUILDING & DRY DOCK CO.
P.O. Box 537
Baltimore, Maryland 21203

Kenneth R. DeBusk
Hull Superintendent

Pat Donahue
Asst. Foreman, Mold Loft

James Forsyth
Manager-Planning & Quality Control

Roy T. Shiflet, Jr.
Engineering Tech.

Richard W. Warfield, Jr.
Supv. Tech. Computer Center

McDERMOTT SHIPYARDS
P.O. Box 188
Morgan City, Louisiana 70380

Rajan Bhambhani
Technical Assistant to Div. Manager

Ken Tabor
N/C Supervisor

McDermott SHIPYARDS
P.O. Box 128
New Iberia, Louisiana 70560

Mitch Hoffpauir
N/C Supervisor

Walter Muffoletto
Technical Assistant

McDONNELL DOUGLAS AUTOMATION COMPANY
P.O. BOX 516
St. Louis, Missouri 63166

Carol Ross
Application Analyst

MITSUI ENGINEERING & SHIPBUILDING CO., LTD.
Chiba Shipyard
Tokyo 104, Japan

Kenzoo Kobayashi
MAPS-GP Group Leader

Tsuneo Nakada
Engineer

NATIONAL CENTER FOR PRODUCTIVITY
& QUALITY OF WORKING LIFE
2000 M Street, N.W. - Suite 3000
Washington, D.C. 20036

Lou Alfeld
Director, Construction Industry
Programs

Jeffery Hallett
Asst. Director

NATIONAL STEEL & SHIPBUILDING CO.
P.O. BOX 80278
San Diego, California 92138

L. E. Hoffman
General Foreman-Material Handling Div.

John Lightbody
Directory of Operations Planning

NATIONAL STEEL & SHIPBUILDING CO. (Contd.)
P.O. Box 80278
San Diego, California 92138

Andy Parikh
Asst. Program Manager

Don Spanninga
Gen'l Mgr., Info. Systems Dept.

Jack Wasserboehr
Sr. Programmer/Analyst;

HQ NAVMAT
Dept. of the Navy
Washington, D.C. 20360

William F. Holden
Mfg. Tech. (Tech. Adm.)

NAVAL MAT'L INDUSTRIAL RESOURCE OFFICE
Bldg. 537.2, Naval Base
Philadelphia, Pennsylvania 19112

Louis F. Walton
Project Engineer (Mech.)

NAVAL OCEANS SYSTEMS CENTER
Mfg. & Prod. Engr. Br., Code 9323
San Diego, California 92152

Robert H. Shade
Supv. Industrial Engineer

NAVAL SEA SYSTEMS COMMAND
U.S. Navy Dept.
Washington, D.C. 20362

Harry J. Peterson
Industrial Engineer

NAVAL SHIP ENGINEERING CENTER
National Center 2-Room 6N18
Washington, D.C. 20362

Arthur L. Fuller
Head, Computer Applications Section

Thomas P. Gallagher
Head, Research Dynamics/High Performance
Craft Section

Thomas M. Sauer
Naval Architect

DAVID TAYLOR NAVAL SHIP RESEARCH
& DEVELOPMENT CENTER
Bethesda, Maryland 20084

Al Cinque
Project Engineer

Tom Corin
Head, Computer Aided Design Div.

Harry Sheridan
Supv. Marine Engr.

Bernard M. Thomson
Hull Group Leader

NEWPORT NEWS SHIPBUILDING & DRY DOCK CO.
4100 Washington Ave.
Newport News, Virginia 23607

Douglas F. Carneal
Mgr-Production Computer Systems

A. F. Kaun
Supervisor-Prod. Comp. Sys. Dept.

Kenneth W. Pleasant
Mold Loft Supervisor

Keith Rayhorn
Senior N.C. Programmer

P. W. Rourke
Supervisor-Engrg. Tech. Dept.

NORFOLK SHIPBUILDING & DRY DOCK CORP.
P.O. Box2100
Norfolk, Virginia 23501

Richard S. Gray
Project Coordinator & Contract Admin.

PETERSON BUILDERS, INC.
101 Pennsylvania
Sturgeon Bay, Wisconsin 54235

Gerard L. Huber
Data Processing Systems Analyst

Ellsworth Peterson
President

PORT ALLEN MARINE SERVICE, INC.
P.O. BOX 108
Port Allen, Louisiana 70767

W. B. Gaines
Project Manager

PORT WELLER DRY DOCKS
P.O. Box 3011
St. Catharines, Ontario, Canada
L2R 7C1

Jesse Harkey
Manager, Computer Systems

B. Waring
Manager, Planning & Control

RAYCHEM CORPORATION
2341 Jefferson Hwy-Suite 1030
Arlington, Virgina 22202

Kenneth C. Frederick
District Manager

RTL, INC.
16421 S. Avalon Blvd.
Gardena, California 90248

M. R. Ward
President

SHIPBUILDING CONSULTANTS, INC.
202 W. Bayou Drive
Dickinson, Texas 77539

Frank H. Rack
President

SHIPPING RESEARCH SERVICES, INC.
One Allen Center, Suite 2250
Houston, Texas 77002

S. A. Hansen
Manager

A. Manchinu
V.P.

SHIPPING RESEARCH SERVICES A/S
H. J. Brantings Vei 8
Oslo 5, Norway

P. Sorensen
Marketing Director,

SPAR ASSOCIATES, LNC.
20 S. Cherry Grove Ave.
Annapolis, Maryland

Laurent C. Deschamps
President

ST. LOUIS SHIP
Pott Industries, Inc.
611 E. Marceau
St. Louis, Missouri 63111

Ronald Farney
Superintendent

John Kennedy
Director of Mat'l Mgmt.

Byron L. Martin
Planning & Control Manager

John Metzger
General Foreman

John J. Mills
Dir. of Bus. Info. Systems

James R. Predeau
Production Planner

Richard J. Querrey
General Manager

SUN SHIPBUILDING & DRY DOCK CO.
Morton Ave.
Chester, Pennsylvania 19013

Joseph E. Herz
Manager, Structural Engineering

Ramesh P. Kakad
Senior Analyst/Programmer

Larry LIddle
Manager, Research Contracts

Eugene Schorsch
V.P.

TACOMA BOATBUILDING CO., INC.
1840 Marine View Dr.
Tacoma, Washington 98422

Gordon Plancich
Manager, N/C Services

Travis E. Short
Director Production Engineering

UNIMATION, INC.
Shelter Rock Lane
Danbury, Connecticut 07810

Torsten H. Lindbom
V.P. - Engineering

UNION CARBIDE CORPORATION
Linde Welding Products
5700 W. Raymond St.
Indianapolis, Indiana 46241

Russell M. Morgan
Manager of Engineering

UNITED COMPUTING CORPORATION
22500 S. Avalon Bivd.
Carson, California 90745

Bill Enoch
Manager, Unigraphics Products

UNIVERSITY OF UTAH
Computer Science Dept.
Salt Lake City, Utah 84112

Andreas Neichbrodt
Graduate Student

ZIGLER SHIPYARD
P.O. Box 1190
Jennings, Louisiana 70546

James Larke
Programmer

F. Y. Martin
V.P. Div. Mgr.

J. O. Pirozzolo
President

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Transportation Research Institute
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Ann Arbor, MI 48109-2150

Phone: 734-763-2465
Fax: 734-763-4862
E-mail: Doc.Center@umich.edu